THE AUSTRALIAN

Entomologist

published by
THE ENTOMOLOGICAL SOCIETY OF QUEENSLAND

Volume 43, Part 3, 3 September 2016
Price: $8.00 per part
ISSN 1320 6133

THE AUSTRALIAN ENTOMOLOGIST
ABN#: 15 875 103 670

The Australian Entomologist is a non-profit journal published in four parts annually by the Entomological Society of Queensland and is devoted to entomology of the Australian Region, including New Zealand, New Guinea and islands of the south-western Pacific. The journal is produced independently and subscription to the journal is not included with membership of the society.

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COVER

Tellervo zoilus (Fabricius), mating in rainforest understory at Mission Beach, northern Queensland. This species is one of a handful of true understory dwelling butterflies in Australia. Males form leks, mating dances of several individuals, in sunny patches in the morning. Females approach, then are led by a male to the underside of a nearby leaf where copulation ensues. Sometimes the female leads and initiates genital contact. As in many butterflies, the male, right, enters a catatonic state during ejaculation. Pen and ink drawing by Caloundra ESQ member, Dr Albert Orr, whose illustrated books on butterflies and dragonflies have won awards in Australia and overseas. His second book on New Guinea Odonata has just appeared (see *Australian Entomologist* **43** (1): 38).

RE-IDENTIFICATION OF AN EXOTIC BEE INTRODUCED TO THE HUNTER VALLEY REGION, NEW SOUTH WALES – *SELADONIA HOTONI* (VACHAL, 1903) (HYMENOPTERA: HALICTIDAE)

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Abstract

In 2004 and 2006, well-established populations of an exotic halictine bee were found in the Upper Hunter Valley region of New South Wales, Australia. On the basis of morphology, the species was identified as *Halictus (Seladonia) smaragdulus* Vachal, 1895 by an expert familiar with that genus. Subsequently, it was discovered that there are six species in the *S. smaragdula* complex, but none of the six had the same mitochondrial DNA barcode as the species found in Australia. The introduced bee has been shown to be conspecific with an African species by mitochondrial COI DNA sequences and identified as *Seladonia hotoni* (Vachal, 1903) by morphology.

Introduction

The initial report of a small, metallic green exotic bee in the Hunter Valley (Gollan *et al.* 2008) identified it as belonging to the western Palaearctic species *Halictus (Seladonia) smaragdulus* Vachal, 1895. Accepting the raising of *Seladonia* Robertson to generic level (Pesenko 1999), the name became *Seladonia smaragdula* (Vachal) Identification was based on the external morphology of specimens sent to A. W. Ebmer, an expert in *Seladonia* taxonomy.

Other features of the male genitalia, however, indicated that *S. smaragdula* was in fact a species complex (Pauly and Rassel 1982), which led the present authors to exchange images, comparison of which suggested that the bees in Australia might belong to one of the other species in the complex. Subsequently, molecular evidence was shown to support the idea of a species complex (Schmidt *et al.* 2015), which now includes *S. smaragdula* and five additional cryptic species (Pauly *et al.* 2015).

Comparison of DNA barcoding sequences of Australian specimens with those of a member of the *S. smaragdula* complex with similar male genitalia (*S. orientana* Pauly & Devalez, 2015), showed that the species were different (*vide infra*). Indeed, the species introduced to Australia was none of the six in the *S. smaragdula* complex. We report here that the introduced species has been shown by morphological and molecular evidence to be the southern African species *Seladonia hotoni* (Vachal, 1903).

DNA barcoding

DNA was extracted from an African *S. hotoni* specimen and sequenced as described previously (Pauly *et al.* 2015). Australian material was treated similarly, but using the DNeasy Blood and Tissue Extraction kit distributed by QIAGEN Pty Ltd and the ExoSAP-IT PCR purification system (USB Corporation). Partial mitochondrial COI sequences (658 bp) were obtained from 36 Australian specimens collected at twelve different locations and a South African specimen collected at Knersvlakte, along Gemsbokrivier Pad, in Western Cape Province (*leg.* M. Kuhlmann).

The COI sequences for the Australian specimens contained two haplotypes with a divergence of 0.5% in roughly equal proportions (20 type 1, 16 type 2). All but one of the differences between the sequences were in the third codon position. Both haplotypes differed from that of *S. hotoni* from Africa by less than 1% (Table 1), whereas they differed from those of the *S. smaragdula* complex by more than 7%. Interspecific differences between species in the *S. smaragdula* complex are between 3% and 6%, while intraspecific variation ranges from 0.2% to 2.7% (Pauly *et al.* 2015).

Table 1. Divergences (number of substitutions/length of sequence) between haplotypes of *Seladonia hotoni* from Africa and Australia (GenBank accession numbers KX360229-31) and other *Seladonia* species available in GenBank (KT601640-KT601694).

	***S. hotoni* (Africa)**	***S. orientana***	***S. smaragdula* species complex**
S. hotoni (Australia)	0.006-0.008	0.084-0.096	0.073-0.135

There was one non-synonymous difference between the two main Australian haplotypes, which corresponds to interchange of valine and isoleucine in the translated protein. Exchange of these hydrophobic amino acids is expected to have a relatively small effect on the protein, but was nevertheless unexpected.

Both the Australian haplotypes were found at 6 of 8 places where more than one specimen was collected. The uniform distribution of the haplotypes and the divergence between them is evidence that the introduction involved more than one individual. *Seladonia hotoni* is known to nest in the ground and nests have been found at Muswellbrook and Sans Souci. One possibility, therefore, is that the bees might have arrived in nesting tunnels in soil.

Morphology

Seladonia hotoni is very similar to *S. smaragdula sens. lat.* and the two can be easily confused when their geographic origin is unknown. The holotype of *S. hotoni* has been examined (by AP) and, while the species cannot be distinguished from *S. submediterranea* Pauly, 2015 or *S. orientana* using the male genitalia, it does differ in other subtle characters. *Seladonia hotoni* has

a shorter head (length/width: female = 0.91, s.d. 0.02, n 25; male = 0.98, s.d. 0.02, n 14) and small differences in surface sculpture. The African species of *Seladonia* have been catalogued by Pauly (2008). They are now illustrated and mapped on the website Atlas Hymenoptera (Pauly 2016).

Predicted distribution of *Seladonia hotoni* in Australia

The introduced species was surveyed between October 2008 and February 2010. In order to determine the potential extent of the incursion and guide further surveys, predicted distributions were calculated using various combinations of Worldclim predictors and the known distribution of *S. smaragdula sens. lat.* (Ashcroft *et al.* 2012). Irrespective of the merits of any particular model, it was of interest to know whether the re-identification altered the predicted distribution of the introduced species. Figure 1 compares predictions for the two groups calculated with Maxent version 3.3.3k with default values for regularisation parameters (Phillips *et al.* 2006) using four commonly used Worldclim parameters: annual mean temperature; annual precipitation; maximum temperature of warmest month and minimum temperature of coldest month. It showed that *S. hotoni* has a higher probability than *S. smaragdula* of colonising southern areas of Australia.

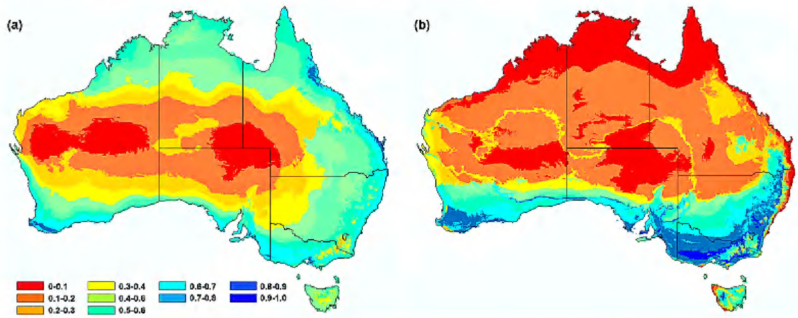

Fig. 1. Logistic output from Maxent using four commonly used predictors for (a) *S. smaragdula sens. lat.* and (b) *S. hotoni*.

New survey and conclusion

A brief survey was conducted on 5 and 6 December 2015 to determine whether the bee was still present in the Hunter region. Ten sites from which the bee had previously been collected were visited and *S. hotoni* specimens were taken at 7 of those sites. Few flowers of any kind is one reason for its absence at the other three sites. Perhaps unsurprisingly, high densities of flowers, especially the introduced species *Galenia pubescens* (Aizoaceae), were associated with many of the collections when sweeping. While there are no specific flower visiting records for *S. hotoni* in Africa, small *Seladonia* species are frequently found on *Galenia sarcophylla* (M. Kuhlmann pers. comm.), which is widespread in the southwestern corner of the continent, an

area that covers about half the known range of *S. hotoni.* No reports have been received of the species spreading to new areas but, equally, no systematic surveys have been performed.

The genus *Seladonia* contains a number of species that can be difficult to distinguish. Correct identification of the species introduced to Australia has required detailed morphological study of species within the genus (Pauly *et al.* 2015), supported by molecular barcoding. The revised identity is consistent with a higher predicted suitability of the Hunter Valley region. Nevertheless, our previous conclusion (Ashcroft *et al.* 2012) that suitable nesting sites may be just as important as climatic variables remains. The presence of two distinct mitochondrial haplotypes throughout the introduced population means that the introduction included more than one individual.

Acknowledgements
We thank Natalie Sullivan and Dr Rebecca Johnson for valuable assistance and advice with the processing of DNA from Australian specimens and M. Kuhlmann for the specimen collected in South Africa.

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FIRST AUSTRALIAN RECORD OF *PARTHENOS TIGRINA* (M. SNELLEN VAN VOLLENHOVEN, 1886) (LEPIDOPTERA: NYMPHALIDAE: NYMPHALINAE)

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Abstract

Parthenos tigrina cynailurus Fruhstorfer, 1915 is recorded from Saibai, Dauan and Mer (Murray) Islands, Torres Strait, Queensland, Australia for the first time. The circumstances of this event are described and its significance as a random dispersal rather than a true migration is discussed.

Introduction

The genus *Parthenos* Hübner, 1819 contains three species occurring throughout the Indo-Australian Region from Sri Lanka and India to New Guinea and the Solomon Islands, with all three species occurring on the island of New Guinea (Parsons 1998). *Parthenos sylvia* (Cramer, 1775) is widespread, its range extending from Sri Lanka and India to the Solomons (Parsons 1998). D'Abrera (1978) recognised 16 subspecies, with *P. s. guineensis* Fruhstorfer, 1898; *P. s. couppei* Ribbe, 1898; *P. s. admiralia* Rothschild, 1915; and *P. s. thesaurus* Matthew, 1887 occurring in New Guinea. The subspecies *P. s. guineensis* occurrs on mainland Papua New Guinea (Parsons 1998). *Parthenos aspila* Honrath, 1888 is confined to northern New Guinea and *P. tigrina* (M. Snellen van Vollenhoven, 1886) is confined to New Guinea (Parsons 1998). D'Abrera (1978) recognised three subspecies of *P. tigrina*, of which only *P. t. cynailurus* Fruhstorfer, 1915 occurs in southern Papua New Guinea.

Little is known of the life history of *P. tigrina* but Parsons (1998) noted that the exuvium of a final instar larva attached to a pupa found at Brown River near Port Moresby by H. Rouber was similar to that of *P. sylvia*. Parsons (1998) noted that *Adenia* and *Modecca* (Passifloraceae) were recorded as larval food plants for *Parthenos*; however, he considered that these records needed confirmation. Parsons (1998) suggested that the woody climbers *Tinospora dissitiflora* Diels and *T. glabra* (Burm.f.) Merr. (Menispermaceae) were the most likely foodplants for *P. sylvia* in lowland Papua New Guinea.

In January and February 2016, numerous adults of *P. t. cynailurus* (Figs 1-2) were observed and collected on Saibai, Dauan and Mer (Murray) Islands, Torres Strait, Queensland, representing a new butterfly record for Australia and Torres Strait. Here we illustrate the butterfly, provide field observations and discuss the dispersal of the butterfly from neighbouring Papua New Guinea.

Abbreviations for specimen repositories: ANIC – Australian National Insect Collection, Canberra; CEMC – C.E. Meyer Collection, Brisbane; CGMC – C.G. Miller Collection, Lennox Head; DALC – D.A. Lane Collection, Atherton; RPWC – R.P. Weir Collection, Bees Creek; SSBC – S.S. Brown Collection, Bowral; TLIKC – Joint collection of T.A. Lambkin and A.I. Knight, Brisbane.

Abbreviations for collectors: CEM – C.E. Meyer; CGM – C.G. Miller; DAL – D.A. Lane; EJLH – E.J.L. Hallstrom; RPW – R.P. Weir; SSB – S.S. Brown; TAL – T.A. Lambkin; WWB – W.W. Brandt.

Material examined

Parthenos tigrina cynailurus Fruhstorfer, 1915
(Figs 1-4)

QUEENSLAND: 1 ♂, Saibai Island, Torres Strait, 22.i.2016, CEM, SSB, RPW & CGM; 8 ♂♂, Dauan Island, Torres Strait, 22-29.i.2016, CEM, SSB, RPW & CGM (in CEMC); 13 ♂♂, Dauan Island, Torres Strait, 22-29.i.2016, SSB, CEM, RPW & CGM (12 in SSBC, 1 in TLIKC); 13 ♂♂, Dauan Island, Torres Strait, 22-29.i.2016, CGM (in CGMC); 11 ♂♂, Dauan Island, Torres Strait, 22-29.i.2016, RPW, SSB, CEM & CGM (in RPWC); 1 ♂, Mer Island, Torres Strait, 29.i.2016, TAL (in TLIKC); 1 ♂, Dauan Island, Torres Strait, 2.ii.2016, DAL (in DALC).

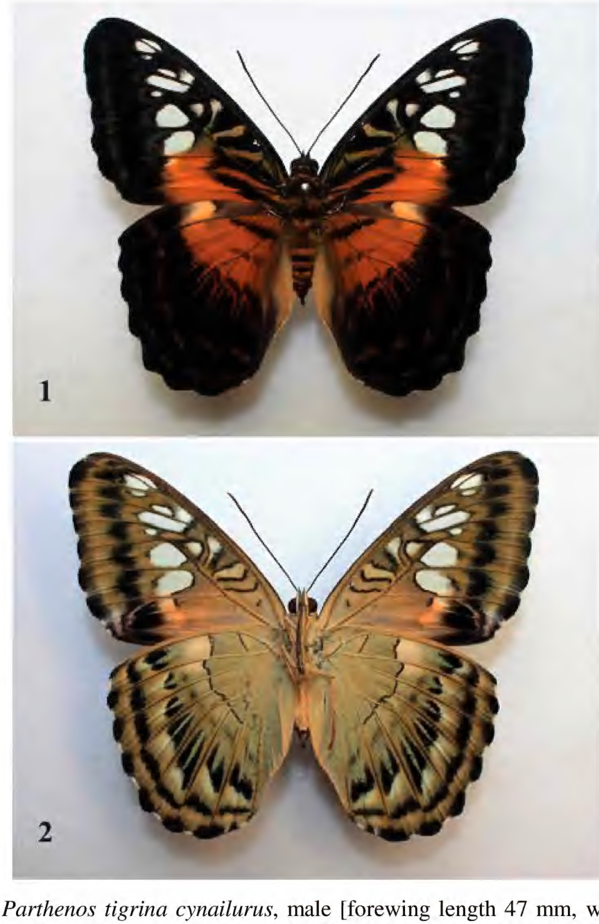
PAPUA NEW GUINEA: 1 ♂, Kiunga, Fly River, 2.vii-31.x.1957, WWB, 10.x.1957 (ANIC Database No. 31 029643); 2 ♂♂, same data except 9.ix.1957 (ANIC Database Nos. 31 029642, 31 029644); 1 ♂, same data except 20.vii.1957 (ANIC Database No. 31 029645); 1 ♂, same data except 15.vii.1957 (ANIC Database No. 31 029647); 1 ♂, Subitana (Central District), 1800 ft, 7.vii.1949, WWB & EJLH (ANIC Database No. 31 029646); 1 ♀, same data except 4.xii.1949 (ANIC Database No. 31 029649); 1 ♀, same data except 24.i.1950 (ANIC Database No. 31 029648); 1 ♀, same data except 9.i.1950 (ANIC Database No. 31 029650).

Observations

On 22 January 2016, the authors observed several specimens of *P. tigrina* flying along tracks and in gardens in the village on Saibai Island, northern Torres Strait. A single specimen was captured by one of us (CEM). Over the following eight days, on nearby Dauan Island, 46 males were examined and many others observed, with numbers estimated to total over 100. Subsequently, on Mer (Murray) Island, eastern Torres Strait, four specimens of *P. tigrina* were observed on 29 January 2016, with one captured. Another was observed on 30 January 2016 but not captured. (T.A. Lambkin and A.I. Knight pers. comm.).

All butterflies examined were newly emerged, although many had wing damage that might have been from bird attack. They flew rapidly, settling briefly to draw nectar from the blossom of various trees growing in the village, predominantly mango, *Mangifera indica* L. and fiddlewood, *Citharexylum spinosum* L. They were observed all over the island in various habitats, from mangroves to open grassy areas, village streets and gardens

and semi-deciduous vine thicket. One was captured on the summit of Mount Cornwallis on Dauan Island at an altitude of 300 m. Their flight was random and generally lacking in purposeful direction. Some were observed flying with the prevailing wind from the Papua New Guinea mainland to the north. Others flew into the wind out to sea and, on a tour around the island by boat, we followed a number for approximately 500 m over water. Others were seen to return to a position several times over about 30 mins after being disturbed. No females were observed or captured.



Figs 1-2. *Parthenos tigrina cynailurus*, male [forewing length 47 mm, wingspan 78 mm], Dauan Island, Torres Strait, 22-29.i.2016, CEM, SSB, RPW & CGM: (1) upperside; (2) underside.

3

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Figs 3-4. *Parthenos tigrina cynailurus*, female [forewing length 45 mm, wingspan 80 mm], Subitana (Central District), 1800 ft, 4.xii.1949, WWB & EJLH (ANIC Database No. 31 029649): (3) upperside; (4) underside.

Also present in larger numbers than recorded in previous years was *Libythea geoffroyi* Godart, 1820 (Nymphalidae: Libytheinae), which was known previously from the Torres Strait islands from only a handful of specimens. Both males and females were encountered in the first three days on Dauan Island, with no more observed for the remainder of the survey.

Unusually for late January, the wet season had not yet begun and conditions were dry with a moderate to strong northerly wind.

Discussion

The butterfly fauna of the Torres Strait islands has been studied intensively over the past 30 years or so and, as *P. tigrina* is a large and conspicuous insect, it is unlikely to have been overlooked previously. There have been no recorded instances of migration in any of the three *Parthenos* species and the non-purposeful flight behaviour of *P. tigrina* observed in the Torres Strait in January 2016 does not agree with the concept of a migration according to Williams (1930).

Parsons (1998) noted that during several days in March 1983 he witnessed numerous adults of *Papilio fuscus* Goeze, 1779, *Catopsilia pomona* (Fabricius, 1775), *Libythea geoffroyi*, *Euploea stephensii* C. & R. Felder, 1865, *Cyrestris achates* (Godart, 1819) and *Yoma sabina* (Stoll, 1780) all purposely moving in a single direction across open town areas of Port Moresby. This seasonal migration at the end of the dry season could explain the increased numbers of *Libythea geoffroyi* encountered by us on Dauan Island.

Parsons (1998) referred to the appearance of large numbers of male *P. tigrina* near Port Moresby after overnight rain, this presumably being a mass emergence. It is highly probable that our observations are the result of dispersal following a similar event on the mainland of Papua New Guinea.

The size of the specimens observed in this survey varied considerably (forewing length 39-50 mm (n = 46)), and this might have been caused by a larger than usual number of larvae competing for a limited supply of the food plant. The apparent mass population movement of *P. tigrina* into Torres Strait recorded here supports the suggestion put forward by Kikkawa *et al.* (1981) that occasional records of some New Guinea species in Cape York Peninsula may be the result of such sporadic dispersals, or even temporary establishment, of New Guinea butterfly species at intervals of many years. The distances involved, approximately 10 km for Dauan and Saibai Islands and 120 km for Mer Island, would not be prohibitive for a powerful flyer with a following wind.

Parthenos tigrina was not observed on Horn or Thursday Islands, 150 km south of Papua New Guinea during our stay from 29-31 January 2016. A further specimen of *P. tigrina* was captured by David Lane on Dauan Island on 2 February 2016, with adults still being observed in lower numbers on Dauan Island and flying over water around and between Dauan and Saibai Islands, up until mid-February 2016 (D. Lane and E. and W. Phillips, pers. comms). No specimens were recorded by Ian Johnson and Peter Wilson during a further survey of Dauan Island in March 2016.

Tinospora smilacina Benth. and *Hypserpa laurina* (F.Muell.) Diels (both Menispermaceae) and *Passiflora foetida* L. (Passifloraceae) are recorded from Dauan Island (Torres Strait Regional Authority 2013) and could be

used, if females were present, by *P. tigrina* as food plants in order to establish a permanent presence on Dauan Island.

Acknowledgements

The authors thank the local community councils and the Elders of Dauan and Saibai Islands for permission to conduct our activities on the islands. We are especially grateful to Liz and Wayne Phillips, Dauan Island State School for their hospitality and assistance. Thanks also to Trevor Lambkin, Ian Knight, David Lane, Ian Johnson and Peter Wilson for permission to include their observations and records of *P. tigrina* from Torres Strait in this paper and to Ted Edwards and You Ning Su, ANIC, for access to the W.W. Brandt collection and provision of the female images respectively.

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A NEW SPECIES OF *SYNEMON* DOUBLEDAY (LEPIDOPTERA: CASTNIIDAE) FROM WESTERN AUSTRALIA

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Abstract

The spring-flying sun-moth *Synemon edwardsi* sp. n. is described from southwestern Western Australia, where it occurs in small isolated colonies in the central and southern wheatbelt. Adults and the male and female genitalia are illustrated. The sun-moth's habitat, larval food plant and flight times are recorded. *Synemon edwardsi* sp. n. is compared with its Western Australian autumn-flying relatives *Synemon gratiosa* Westwood and *Synemon jcaria* R. Felder and with *Synemon laeta* Walker from eastern Australia.

Introduction

In 1948, A.M. Douglas collected the first three specimens of a small sun-moth, with orange and black hind wings, in bushland near the small wheatbelt town of Kukerin in southwestern Western Australia; the specimens were deposited in the Western Australian Museum. No further individuals were seen until Dr Terry Houston obtained a female at Charles Gardner Nature Reserve, 15 km south of Tammin, in 1996. These specimens were subsequently examined by E.D. Edwards, who considered them to be an undescribed species related to *Synemon gratiosa* Westwood and *Synemon jcaria* R. Felder. Genetic analysis has since confirmed that it is a distinct species (Williams *et al.* 2012).

The descriptions of Lepidoptera species published in the mid to late nineteenth Century were often limited to a single paragraph written in Latin, with hand drawn illustrations showing the insect's wing pattern and wing venation. This was the case for the three Castniidae species related to the new species, namely *S. laeta* Walker, *S. jcaria* and *S. gratiosa* (Westwood 1879). Even though these early descriptions are minimal, they offer some help in differentiating the species.

In 2010, surveys were undertaken by the Western Australian Department of Environment and Conservation (now Department of Parks and Wildlife) to determine the distribution and conservation status of the Graceful Sun-moth, *S. gratiosa* (Bishop *et al.* 2010a, b, Gamblin *et al.* 2011, Williams 2012, Williams *et al.* 2012). In conjunction with the Graceful Sun-moth surveys, the distribution of another closely related inland species, *Synemon jcaria*, was also examined. While conducting inland habitat surveys, the undescribed 'Kukerin Sun-moth' was found at several new localities in the Western Australian wheatbelt (Williams and Williams 2013b).

Institutional and private collections in which specimens are located are abbreviated as follows: AKC – Axel Kallies collection, Melbourne; ANIC – CSIRO Australian National Insect Collection, Canberra; WAM – Western Australian Museum, Perth; DPaW – Department of Parks and Wildlife.

Synemon edwardsi sp. n.

(Figs 1-10)

Types. *Holotype* ♂, WESTERN AUSTRALIA: DPaW Database No. C 2011, labelled 'Kukerin Bushland, 21xi.2011, open mallee woodland, sparse shrubs & sedges, 33°10'36.5"S 118°04'20.9"E, A.A.E. Williams, Reg. No. E89245' (in WAM). *Paratypes*: 99 ♂♂, 36 ♀♀: 1 ♀, DPaW Database No. C 2856, North Tarin Rock Nature Reserve, 8.xi.2012, tammar heath, sedges and *Chamaexeros fimbriata*, 32°58'52.6"S 118°16'01.5"E., A.A.E. Williams, Reg. No. E89250 (in WAM); 1 ♂, [label data 48:2950 refers to WAM Specimen Register entry on 24. xi.1948], Kukerin, A.M. Douglas, collection date not recorded (in ANIC on loan from WAM); 1 ♀, Charles Gardner Nat. Res. 15 km S. of Tammin, 21.xi.1996, T.F. Houston 919.6 (in ANIC on loan from WAM); 10 ♂♂, 5 ♀♀, Charles Gardner Nature Reserve, 5.xi.2010, 31°47'27.1"S 117°27'51.4"E, tammar shrubland over sparse low shrubs and sedges, A.A.E. Williams (1 ♂, 1 ♀ in ANIC, 1 ♀ in AKC, remainder in WAM); 2 ♂♂, 2 ♀♀, Charles Gardner Nature Reserve, 11.xi.2010, 31°47'27.1"S 117°27'51.4"E, tammar shrubland over sparse low shrubs and sedges, A.A.E. Williams (in WAM); 1 ♂, 1 ♀, Charles Gardner Nature Reserve, 11.xi.2011, 31°47'25.5"S 117°28'00.7"E, open tammar heath over sparse low shrub sedges, A.A.E. Williams (in WAM); 2 ♂♂, 1 ♀, Charles Gardner Nature Reserve, 12.xi.2011, 31°47'25.5"S 117°28'00.7"E, open tammar heath over sparse low shrub sedges, A.A.E. Williams (in WAM); 1 ♂, 2 ♀♀, Charles Gardner Nature Reserve, 10.xi.2012, 31°47'25.5"S 117°28'00.7"E, open tammar heath over sparse low shrub sedges, A.A.E. Williams (in WAM); 5 ♂♂, 6 ♀♀, Charles Gardner Nature Reserve, 12.xi.2013, 31°47'26.0"S 117°27'51.0"E, *Allocasuarina campestris* over *Chamaexeros fimbriata*, E.D. Edwards and M.R. Williams (in ANIC); 3 ♂♂, Corrigin Bushland Go-cart Track, 8.xi.2010, 32°21'10.6"S 117°51'38.3"E, mallee tammar shrubland over open heath and sedges, A.A.E. Williams (in WAM); 3 ♂♂, Corrigin Bushland Go-cart Track, 8.xi.2010, 32°21'08.1"S 117°51'51.1"E, open *Allocasuarina*, sparse low shrubs and sedges, A.A.E. Williams (2 in WAM, 1 in ANIC); 1 ♂, 1 ♀, Corrigin Bushland Wildflower Trail, 1.xi.2010, 32°20'18.7"S 117°49'55.6"E, tammar shrubland open low shrubs and sedges, A.A.E. Williams (1♂ in WAM, 1 ♀ in ANIC); 2 ♂♂, 1 ♀, Corrigin Bushland Wildflower Trail, 1.xi.2010, 32°20'19.8"S 117°49'57.2"E, tammar shrubland open low shrubs and sedges, A.A.E. Williams (in WAM); 1 ♂, Corrigin Bushland Wildflower Trail, 1.xi.2010, 32°20'20.3"S 117°49'54.7"E, tammar shrubland male on gravel road, A.A.E. Williams (in WAM); 1 ♀, Corrigin Bushland Wildflower Trail, 1.xi.2010, 32°20'18.7"S 117°49'55.6"E, tammar shrubland open low shrubs and sedges, A.A.E. Williams (in WAM); 1 ♂, 1 ♀, Corrigin Bushland, 20.xi.2011, 32°20'18.7"S 117°49'55.5"E, tammar shrubland and open low shrubs and sedges, A.A.E. Williams (in WAM); 2 ♂♂, 1 ♀, Corrigin Bushland, 13.xi.2012, 32°20'23.5"S 117°49'46.2"E, tammar shrubland and open low shrubs and sedges, A.A.E. Williams (in WAM); 4 ♂♂, Corrigin Bushland, 13.xi.2012, 32°20'18.7"S 117°49'55.6"E, tammar shrubland: flying along gravel track, A.A.E. Williams (in WAM); 1 ♀, Frank Hann

National Park, 22.xi.2011, 33°04'48.3"S 120°01'36.7"E, near *C. fimbriata* sedge on western park boundary, A.A.E. Williams (in WAM); 1 ♂, Kukerin Bushland, 1.xi.2010, 33°10'26.6"S 118°04'39.7"E, open mallee and tammar, small shrubs and sedges, A.A.E. Williams (in WAM); 1 ♀, Kukerin Bushland, 21.xi.2011, 33°10'36.5"S 118°04'20.9"E, open mallee woodland sparse shrubs and sedges, A.A.E. Williams (in WAM); 3 ♂♂, Kukerin Bushland, 8.xi.2012, 33°10'35.4"S 118°04'17.4"E, open mallee / shrubland, *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 7 ♂♂, Kulin Bushland, Macrocarpa Drive Trail, 1.xi.2010, 32°39'47.8"S 118°08'27.3"E, mallee / *Allocasuarina* over low shrubs and sedges, A.A.E. Williams (in WAM); 2 ♂♂, Kulin Bushland, Macrocarpa Drive Trail, 8.xi.2010, 32°39'49.4"S 118°08'28.6"E, mallee / *Allocasuarina* over low shrubs sedges, A.A.E. Williams (1 in WAM, 1 in ANIC); 2 ♂♂, 1 ♀, Kulin Bushland, Macrocarpa Drive Trail, 8.xi.2010, 32°39'47.8"S 118°08'27.3"E, mallee and *Allocasuarina* over low shrubs and sedges, A.A.E. Williams (in WAM); 2 ♂♂, Kulin Bushland, Macrocarpa Drive Trail, 8.xi.2010, 32°39'56.0"S 118°08'32.5"E, mallee and *Allocasuarina* over low shrubs and sedges, A.A.E. Williams (in WAM); 3 ♂♂, Kulin Bushland, Macrocarpa Drive Trail, 20.xi.2011, 32°39'49.8"S 118°08'30.2"E, mallee and *Allocasuarina* mixed shrubs and sedges, A.A.E. Williams (in WAM); 2 ♂♂, 1 ♀, Kulin Bushland, Macrocarpa Drive Trail, 20.xi.2011, 32°39'52.6"S 118°08'34.4"E, *Euc macrocarpa* / tammar shrubs and sparse sedges, A.A.E. Williams (in WAM); 1 ♂, Kulin Bushland, Macrocarpa Drive Trail, 23.xi.2011, 32°39'49.8"S 118°08'30.2"E, mallee and *Allocasuarina* mixed shrubs and sedges, A.A.E. Williams (in WAM); 1 ♂, 3 ♀♀, Kulin Bushland, Macrocarpa Drive Trail, 23.xi.2011, 32°39'52.6"S 118°08'34.4"E, *Euc macrocarpa* / tammar shrubs and sparse sedges, A.A.E. Williams (in WAM); 3 ♂♂, Kulin Bushland, Macrocarpa Drive Trail, 7.xi.2012, 32°39'49.8"S 118°08'30.2"E, mallee and *Allocasuarina* mixed shrubs and sedges, A.A.E. Williams (in WAM); 6 ♂♂, 1 ♀, Kunjin Bushland, 12 km WSW of Corrigin, 7.xi.2012, 32°20'56.9"S 117°46'15.0"E, mallee, tammar, Melaleuca over *Chamaexeros fimbriata*, A.A.E. Williams (in WAM, one aberrant male, cream hind wings); 1 ♂, Kunjin Bushland, 12 km WSW of Corrigin, 13.xi.2012, 32°21'06.0"S 117°46'12.8"E, mallee, tammar, *Melaleuca* over *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 4 ♂♂, 2 ♀♀, Kunjin Bushland, 12 km WSW of Corrigin, 13.xi.2012, 32°21'06.0"S 117°46'12.8"E, mallee, tammar, *Melaleuca* over *Chamaexeros fimbriata*, A.A.E. Williams (3 ♂♂, 2 ♀♀, in WAM, 1 ♂ in AKC); 1 ♂, North Lomos Road, 25 km west of Corrigin, 13.xi.2012, 32°21'26.2"S 117°36'37.2"E, tammar shrubland over *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 14 ♂♂, 2 ♀♀, North Tarin Rock Nature Reserve, 8.xi.2012, 32°58'52.6"S 118°16'01.5"E, tammar heath, sedges and *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 1 ♂, Overhue Nature Reserve, 7.xi.2012, 32°22'18.8"S 117°34'50.9"E, tammar shrubland over *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 5 ♂♂, Overhue Nature Reserve, 13.xi.2012, 32°22'23.4"S 117°34'58.3"E, tammar shrubland over *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 1 ♂, Tarin Rock Nature Reserve, 8.xi.2012, 33°06'26.5"S 118°12'25.5"E, open mallee heath, sedges, *Chamaexeros fimbriata*, A.A.E. Williams (in WAM).

Description. Holotype male (Figs 1-2). Head prominent; eyes large and rounded, eye surface very finely faceted, eye colour olive brown evenly spotted dull black in fresh specimen. Top of head densely scaled from between antennae and eyes to frons; each scale grey-brown with whitish

serrated ends or bifurcate tips. A line of long white vertical piliform hair-scales is located immediately behind the eyes and antennal bases. Antennae clubbed, antennal length 8.5 to 9 mm, extending less than half way along the forewing costa. Antennal shaft slender, evenly scaled black with seventeen evenly spaced narrow white segmental bands; white bands narrow above, more diffuse on underside of shaft. Antennal tip clubbed, club with short finely pointed tip. Scales on upperside of antennal club black, scales on underside of club predominantly white from base towards tip. Nudum narrow 8-10 flagellomeres. Labial palps densely covered in white scales that partially obscure a very short rudimentary proboscis; proboscis length <2.0 mm. De-scaled labial palp reveals a bulbous basal segment and a long tapered mid segment attached at right angles and pointing anteriorly; the apical segment is small and short. [Proboscis and labial palps preserved in alcohol vial V518 – ex specimen # C 1091]. Thorax large, central portion of mesothorax dark grey, almost bare, but with some flattened scales and short white scale hairs. Prothorax and dorsolateral region of mesothorax above wing bases densely covered with a crescent-shaped shield of slightly raised overlapping scales, each scale grey-brown tipped whitish grey. A cluster of semi-erect dorsolateral elongate blackish-grey scales is located just above the base of the forewing. [These erect scales form the settled posture 'shoulder tufts' so characteristic of this sun-moth species group (Williams and Williams 2013a)]. Metathorax scales at junction with the abdomen are overlain with tufted long brown hairs emanating from the pleuron immediately behind the hindwing bases. Sternum covered with long whitish scales and hairs. Legs with white scales; tarsi on each leg with numerous short and acute posteriorly facing spines. Epiphysis short, with rounded tip, covered in short spines not nearly reaching the end of the foretibia. Abdomen above orange-brown covered in small round scales; anal tuft conspicuous, composed of narrow elongate orange-brown scales tipped whitish. Underside of abdomen grey-brown, banded with whitish scales at abdominal segment joints. Forewing: moderately slender, base to apex 14.5 mm, costa almost straight, slightly curved inwards near tip, apex pointed. Termen gently curved outwards, dorsum initially straight, angled inwards at midpoint to wing base attachment; upper surface entirely covered with slightly elongate serrated edged scales. Venation with accessory cell formed by anastomosis of the stem of R4+5 and R3 (Fig. 5). Upperside ground colour grey, paler in central subterminal to median area between two parallel indistinct broken black lines. The inner line of indistinct black markings runs from above the angled dorsum and culminates in three elongate postmedian black markings along M_1, M_2 and M_3 near the costa. The outer line of indistinct black subtornal-subterminal spots runs parallel to the termen. The forewing termen is narrowly edged grey-brown, with fringing scales whitish grey, tipped grey-brown. Hindwing: comparatively small and rounded; upper surface covered with small rounded scales, scale edges smooth, occasionally minutely

serrated. Hindwing upperside ground colour black, with broad deep bright orange postmedian band from 1A+2A to M_1. Large deep bright orange discal patch located between CuA_1 and M_1. Orange hindwing patches separated by an irregular but unbroken black crossband. Outer border black, termen fringe scales whitish grey tipped grey-brown except for small patch of white fringe scales towards apex. Underside of wings: forewing scales variable, both rounded and serrated; ground colour brownish grey merging to pale grey in subtornal-dorsum area; prominent black subapical spot from which three smaller elongate white markings extend towards apex; subcostal area from wing base to subterminal line and median area dull orange, enclosing two almost confluent median-subcostal black spots. Hindwing underside scales usually serrated; ground colour black, apex grey; underside orange markings similar to above but extending to the basal area and inner dorsum alongside the abdomen; lower subbasal area and inner margin above dorsum overlain with long golden hair-scales arising from hindwing base. Frenulum long, pointed, dark brown (Fig. 6).

Figs 1-4. *Synemon edwardsi* sp. n.: (1-2) male upper and undersides, Kukerin Bushland, C 2011 (WAM); (3-4) female upper and undersides, North Tarin Rock Nature Reserve, C 2856 (WAM).

Female (Figs 3-4) similar to male but usually larger. Forewing broad and rounded, hind wing also rounded and proportionately larger than that of the male. Forewing upperside pattern similar to male but black markings often more distinct (Fig. 3). Hindwing upperside pattern more pronounced, the deep bright orange postmedian band extending into the inner dorsum margin alongside the abdomen (Fig. 3). This postmedian band is separated more clearly from the deep orange discal patch by a broad black crossband that joins the heavy black outer border. The female underside resembles the male, but the deep orange colouration is brighter and far more extensive.

Variation. There is considerable variation in the black markings on the upperside of the forewing in this species. In some individuals the markings are indistinct; in others the inner line markings may be almost confluent, forming a more distinct line. The outer line of spots parallel to the termen may also be bold and more pronounced, especially in females. One aberrant male from Kunjin Bushland, west-south-west of Corrigin, has cream rather than deep bright orange hindwing colouration. Male wingspan varies from 26-32 mm, female wingspan from 30-35 mm.

Male genitalia (Figs 7-9). Uncus short, broadly rounded with a few short setae; gnathos arms broad flat plates fused below; anal tube well sclerotised; tegumen broad, expanding to very broad where it joins the vinculum; vinculum sharply angled and poorly sclerotised above angle; saccus with broadly bifurcated arms; juxta well developed, bent sharply backwards to a point; valva compact, almost quadrate with prominent upturned spine at tip with numerous short setae and costa with stout setae; aegeagus moderately long, well sclerotised, broad and broadening anteriorly with phallobase sharply recurved, with flattened tip; ductus ejaculatorius much longer than aedeagus, with numerous coils.

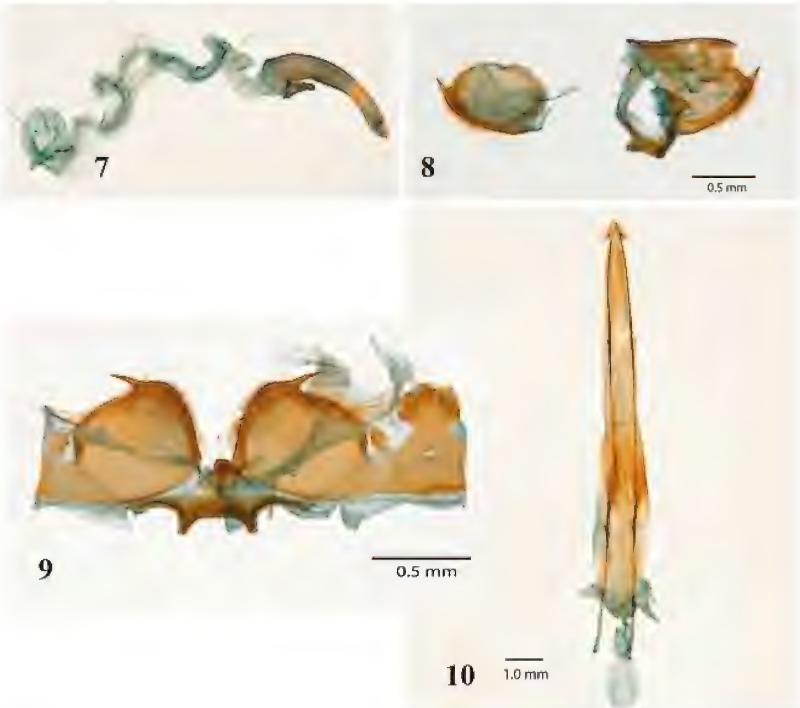
Female genitalia (Fig. 10). Papillae anales short-pointed, sclerotised; ovipositor long, fairly narrow, extensible, sclerotised, with stout lateral hairs towards tip, numerous fine setae near base; apophyses long, heavily sclerotised; sinus vaginalis with sclerotised thickening; ostium bursae at posterior edge of sternum 7; ductus bursae long, narrow, tightly coiled; corpus bursae spherical without signum.

Etymology. This species is named in honour of E.D. (Ted) Edwards, a world authority on the Australian Castniidae, in recognition of his significant contribution to our present knowledge of the Australian sun-moth fauna.

Proposed English name. Splendid Sun-moth.

Larval food plant. The larval food plant is *Chamaexeros fimbriata* (F. Muell.) Benth. (Asparagaceae), a species very closely related to the matt-rush genus *Lomandra* (Asparagaceae), which is utilised by members of the same species group, *S. gratiosa*, *S. jcaria* and *S. laeta* (see Table 1).

Figs 5-6. *Synemon edwardsi* sp. n., male wing venation, Corrigin (Slide M-18641 (ANIC)): (5) forewing; (6) hind wing and frenulum.



Figs 7-10. *Synemon edwardsi* sp. n.: (7) male genitalia showing aedeagus, Charles Gardner Nat. Res. (Slide M-13638 (ANIC)); (8) male genitalia, aedeagus removed, right valva removed and placed on left of photo, remainder viewed from right side, Charles Gardner Nat. Res. (Slide M-13638 (ANIC)); (9) male genitalia, cut laterally on right side, spread and flattened, Charles Gardner Nat. Res. (Slide M-13639 (ANIC)); (10) female genitalia, Charles Gardner Nat. Res. (Slide M18640 (ANIC)).

Table 1. Diagnostic features and flight times for *Synemon edwardsi, S. gratiosa, S. jcaria* and *S. laeta.*

SPECIES	AVERAGE WING SPAN	FOREWING UPPERSIDE	HINDWING UPPERSIDE	PROBOSCIS	FLIGHT PERIOD
S. edwardsi	♂ 30 mm ♀ 32 mm	Uniform grey above with two oblique parallel broken black lines	Deep bright orange with a broad black border, solid black central band	Very short rudimentary proboscis	November
S. gratiosa	♂ 24 mm ♀ 30 mm	Variably patterned above with cryptic grey, black and whitish forewing markings	Orange with blackish border, centre unmarked or with variable blackish markings, sometimes with a curved black crossband. Blackish subbasal spot usually absent.	Very short rudimentary proboscis	Feb - April
S. jcaria	♂ 32 mm ♀ 38 mm	Variably patterned above with cryptic grey, black and whitish forewing markings	Orange with blackish border, partial or complete curved black central band, blackish subbasal spot almost always present.	Very short rudimentary proboscis	Jan - March
S.laeta	♂ 35 mm ♀ 42 mm	Ground colour grey to grey-brown, with three black to blackish patches forming distinct partial bands across the forewing.	Orange with broad black border and solid black crossband. Distinct blackish spot at base of hindwing.	Short coiled but apparently functional proboscis	Oct - Mar

Note: *Synemon edwardsi and S. gratiosa* are Western Australian species; *S. jcaria* is found in eastern and Western Australia, while *S. laeta* occurs in eastern Australia.

No detailed life history information is available for *S. edwardsi* apart from the fact that mid stage and mature larvae were found in the rhizomes of *C. fimbriata* plants at Charles Gardner Nature Reserve in November 2010. This suggests the life cycle may take two or more years to complete.

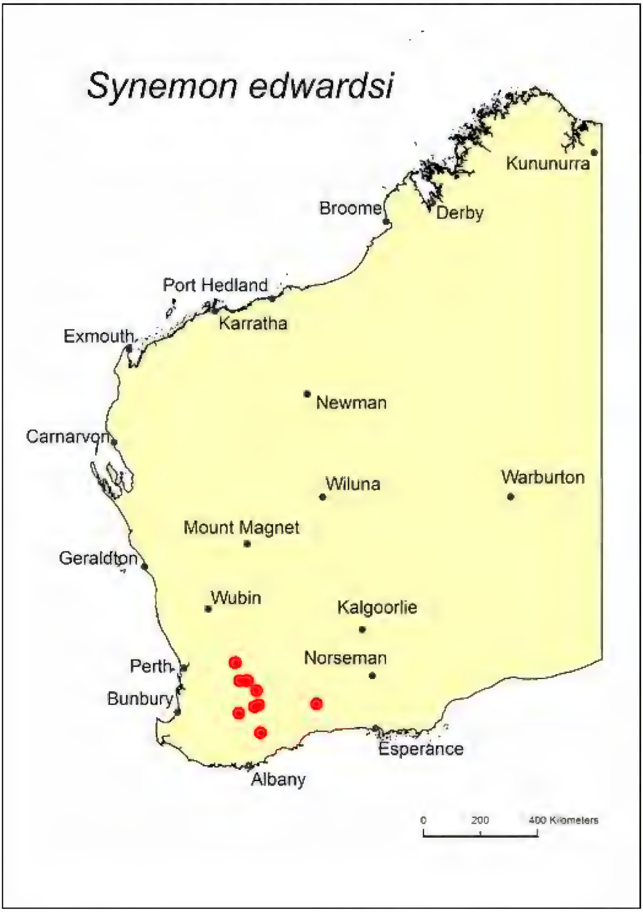


Fig. 11. Map of Western Australia showing distribution of *Synemon edwardsi.*

Distribution. The species is currently known from ten localities in the central and southern wheatbelt (Fig. 11): Charles Gardner Nature Reserve, Corrigin Bushland (now a Nature Reserve), Kunjin Bushland, native bushland alongside North Lomos Road near Corrigin, Kulin Bushland, Tarin Rock Nature Reserve, Overhue Nature Reserve, North Tarin Rock Nature Reserve,

Kukerin Bushland and the western boundary of Frank Hann National Park. The nine westernmost sites between Charles Gardner Nature Reserve and Kukerin Bushland are all isolated patches of native vegetation surrounded by cleared farmland. Only the outlying southeastern population on the western boundary of Frank Hann National Park adjoins a large expanse of uninterrupted native bushland.

Recognition. *Synemon edwardsi* can be readily distinguished from the two Western Australian species *S. jcaria* and *S. gratiosa*. These two autumn-flying sun-moths are morphologically similar, although most specimens of *S. jcaria* (Figs 16-19) are noticeably larger, more heavily marked and have more extensive underside white spotting than typical *S. gratiosa* (Figs 12-15) (Williams *et al*. in prep.).

Figs 12-15. *Synemon gratiosa*: (12) ♂ dorsal, Tamala Park, Perth; (13) ♂ ventral, Tamala Park, Perth; (14) ♀ dorsal, Yanchep, Perth; (15) ♀ ventral), Yanchep, Perth.

Figs 16-19. *Synemon jcaria*: (16) ♂ dorsal, Namelkatchem Nature Reserve; (17) ♂ ventral, Namelkatchem Nature Reserve; (18) ♀ dorsal, Drummond Nature Reserve, Toodyay; (19) ♀ ventral, Drummond Nature Reserve, Toodyay.

Synemon edwardsi can be readily identified in the field, being the only sun-moth of this size and colouration flying in the Western Australian wheatbelt in November (Figs 20-21).

Habitat. *Synemon edwardsi* is always found in close proximity to its larval food plant, *C. fimbriata* (Figs 22-23), which grows on sandy-clay soils. The sun-moths most frequently occur in open mallee / shrubland over open low heath with *C. fimbriata*, or within Tamma, *Allocasuarina campestris*, dominated shrubland where the ground cover is very open, low *Borya* sp. with scattered small sedges and tussocks of *C. fimbriata*. The presence of the larval food plant does not necessarily ensure that the sun-moth is present.

Behaviour and flight period. This small, fast-flying sun-moth occurs in isolated colonies where it invariably flies close to the ground. Males set up territories in areas of open ground and, where available, will frequently use low termite mounds as perching points (Fig. 23) (Williams and Williams 2013b). The flight period is very short, in some cases lasting only 2 weeks.

Figs 20-21. *Synemon edwardsi* sp. n.: (20) male basking posture, hindwing upperside exposed; (21) male settled closed-wing posture, showing elongate pointed forewing with diagnostic indistinct parallel broken black lines (photos by Andrew Williams).

Figs 22-23. (22) Typical habitat for *Synemon edwardsi* – note the large *Chamaexeros fimbriata* tussock plant to the left of the termite mound; (23) *Synemon edwardsi* larval food plant, *Chamaexeros fimbriata* (photos by Andrew Williams).

Adults fly in November, but the exact date of their emergence depends on annual weather conditions. In dry years the species appears in very early November but in cooler, wetter seasons does not fly until later in the month (Williams and Williams 2013b). The sun-moths are active in warm to hot sunny conditions and, like other species, will settle when cloud cover appears.

Conservation status and management implications. In view of predicted drying trends for the Western Australian wheatbelt, this sun-moth may be regarded as threatened in the northern parts of its range where it is restricted to a few small remnant patches of native vegetation (Williams and Williams 2013a). Only if the species is found in the more extensive moister southern native bushlands in and near Frank Hann National Park, where its larval food plant is known to occur, can its status be regarded as more secure.

Discussion

The original three *S. edwardsi* specimens were collected by Athol Douglas. Two of these have not been located; the third is in the Australian National Insect Collection in Canberra, on loan from the Western Australian Museum. The only information on the original specimen label is 48.2950. This refers to a 1948 acquisition entry in the WA Museum Register on 24th December 1948. The specimens were probably collected on a field trip in November 1948 and deposited in the WA Museum collection the following month (Brian Hanich, WAM Invertebrate Collection Manager, pers. comm.). Almost five decades later, Dr Terry Houston secured a female at Charles Gardner Nature Reserve on 21 November 1996. His field notebook records 'Flying at 3:30 pm in *Borya* / sedge area and perched on dead stem 40 cm high – castniid.' (T.F. Houston pers. comm.). Recent searches at Charles Gardner Nature Reserve ultimately resulted in the location of a population of *S. edwardsi* there and the identification of *C. fimbriata* (Fig. 23) as its larval food plant. The Department of Parks and Wildlife's Florabase website provided location data for other *C. fimbriata* sites where *S. edwardsi* might be expected to occur. Targeted surveys at these locations resulted in the ten confirmed *S. edwardsi* localities listed above.

Synemon edwardsi belongs to a group of four allied sun-moths, the other three being *S. gratiosa*, *S. jcaria* and *S. laeta*. This group is characterised by the presence of an accessory cell in the forewing and the Asparagaceae feeding habit of the larva. It shares the compact valva and the presence of sensory hairs near the base of the ovipositor with the *S. magnifica* group. *Synemon edwardsi*, *S. gratiosa* and *S. jcaria* all occur in southwestern Western Australia (Williams and Williams 2013b), while *S. laeta* is confined to eastern Queensland (CSIRO 2015) and northern New South Wales (Murphy 2015). The flight times of the three Western Australian species differ: *S. gratiosa* and its inland relative *S. jcaria* fly in late summer and autumn, while *S. edwardsi* flies in late spring (Williams and Williams 2013b,

Williams *et al.* in prep.). As the distribution of *S. jcaria* overlaps that of *S. edwardsi* and, in places their respective food plants grow together, it is possible that at some sites the two species coexist but remain temporally separated. It is interesting that both *S. gratiosa* and *S. jcaria* have reduced, barely functional mouthparts and fly at times when flowering plants are not generally available. *Synemon edwardsi* has similarly reduced mouthparts that appear inadequate for normal nectar intake but it flies at times when at least some plants are in flower. *Synemon laeta* from eastern Australia has a short apparently functional proboscis but, like its Western Australian counterparts, is not known to visit flowers (E.D. Edwards pers. comm.).

Genetic analysis has confirmed that *S. edwardsi* is a distinct species, its closest relatives being *S. gratiosa* and *S. jcaria* (Williams *et al.* 2012). The larval food plants for all four sun-moth species belong to the plant family Asparagaceae: *S. gratiosa*, *S. jcaria* and *S. laeta* all feed on *Lomandra* species (Edwards 1997, Edwards pers. comm., pers. obs.). The food plant for *S. edwardsi*, *Chamaexeros fimbriata*, is very closely related to *Lomandra*; indeed, it has been proposed that the genus *Chamaexeros* be included within *Lomandra* (Greg Keighery, Department of Parks and Wildlife, pers. comm.).

Acknowledgements

We are very grateful to Yu Ning Su, CSIRO Australian National Insect Collection, for the genitalia and wing venation slide illustrations, and Brian Hanich and Nik Tatarnic, Western Australian Museum, for the sun-moth photo illustrations. Ted Edwards provided guidance and helpful comments on the original draft manuscript.

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THE GENERA *EOOPHYLA* SWINHOE AND *NYMPHICULA* SNELLEN (LEPIDOPTERA: CRAMBIDAE: ACENTROPINAE) IN FIJI, WITH DESCRIPTIONS OF FOUR NEW SPECIES

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Abstract

The related moth genera *Eoophyla* Swinhoe and *Nymphicula* Snellen from Fiji are reviewed. Seven *Eoophyla* species are fully described, including the newly described *E. albipuncta, E. vitiensis, E. lutea* and *E. montana*, plus three other species newly transferred to *Eoophyla* from three different genera. Previously described *Nymphicula* species from Fiji are included here for completeness and comparison, since they are superficially very similar.

Introduction

Species belonging to a number of genera of the subfamily Acentropinae (previously known as Nymphulinae) show considerable superficial similarity in terms of wing markings. These are small, attractive moths (Fig. 1), with markings similar to those shown in Figs 2-13, the dark marginal spots on the hind wing being particularly characteristic. A collection of moths from Fiji from the years 1991-1998, with a few from later years, included 138 specimens of this general type. In the past, species similar to these have been assigned to a variety of genera, including *Cataclysta* Hübner, *Nymphicula* Snellen, *Eoophyla* Swinhoe, *Aulacodes* Guenée, *Oligostigma* Guenée, *Margarosticha* Lederer and *Anydraula* Meyrick. Yoshiyasu (1980) noted that *Nymphicula* had long been treated as a synonym of *Cataclysta* and that many species had been described under this genus from tropical regions. He proposed the removal of *Nymphicula* from this synonymy, with *Cataclysta* being restricted to a single Palaearctic species, *C. lemnata* (Linnaeus). Speidel and Mey (1999) catalogued the Oriental Acentropinae, moving many species to new generic combinations. They listed *Eoophyla* as the most species-rich genus among those being considered here (49 species), followed by the reinstated *Nymphicula* (22 species).

Ten species belonging to these genera were found in Fiji, including the two *Nymphicula* species (see below). Seven species were assigned to *Eoophyla.* Of these, three were previously described species that are assigned new generic combinations, while four are described as new. The tenth is a single specimen of an apparently undescribed species, which can provisionally be assigned to *Nymphicula* but cannot be fully described as the abdomen is missing.

Agassiz (2014) reviewed *Nymphicula* in Australia, New Guinea and the South Pacific, including descriptions of 23 new species and five existing species, with several new generic combinations. Two of these species, *N. cyanolitha* (Meyrick) (*Cataclysta*) and *N. australis* (Felder & Rogenhofer) (*Margarosticha*) were originally described from Fiji. A number of specimens

of each of these two species were taken during the present study. These species were fully described and illustrated by Agassiz (2014), including male and female genitalia, but illustrations of the adults are included here for the purposes of comparison and completeness, as the wing patterns are superficially similar to those of the *Eoophyla* species. Their distribution in Fiji is also noted.

Eoophyla species are known to be aquatic in their early stages, whereas *Nymphicula* species are terrestrial. Indeed, this is listed by Speidel (1984) as one of the defining features of the genus. No confirmation of these characteristics could be made from the current work, as the early stages were not studied. However, the eastern parts of Fiji have a very wet climate and water was abundant in the forest locations where trapping took place.

Fig 1. Assemblage of *Eoophyla vitiensis* sp. n. in Namosi Province, Fiji.

Materials and methods

A regular programme of light trapping was carried out during the period 1991-1998. This was used to sample the moth fauna at various lowland forest locations in eastern Viti Levu. These included (with approximate geographical coordinates) the provinces of Serua (-18°09´, 178°01´), Namosi (-18°06´, 178°10´) and Tailevu (-17°55´ 178°30´) and in the general Suva area (-18°04´, 178°26´ and -18°09´, 178°26´). A small number of visits were also made to Cakaudrove Province in Vanua Levu (-16°25´, 179°54´). These locations ranged in altitude from sea level to 200 m. Recording also took place in montane forest in Naitasiri Province (-17°43´, 178°01´) at an altitude of 900 m. A battery-powered trap was employed, using a 6W actinic tube as light source. This allowed easier access to more remote locations. A small number of further visits were made up to 2013.

Systematics

The higher classification followed here is that of Regier *et al.* (2012), who confirmed the monophyly of the Acentropinae as a subfamily of the Crambidae.

Family Crambidae
Subfamily Acentropinae
Genus *Eoophyla* Swinhoe, 1900

Swinhoe (1900) defined this genus based on the males having a long hair-tuft contained within a fold on the mid-tibia and both sexes having the hind wing excised below the apex. Speidel (1984) confirmed these as the defining features of *Eoophyla* and they are present in the seven species placed here in this genus, although the hindwing excision is quite minimal in some species. The head, palps and antennae also agree with Speidel's wider generic description and illustration. Speidel and Mey (1999) listed their *Eoophyla* species in five groups. No attempt is made here to consider this or any further grouping for the species under discussion. However, based on the general form of the male genitalia and of the bursa copulatrix, these seven species appear to be closely related. Speidel (1984) noted that, for Palaearctic species, the bursa bore a signum consisting of two longitudinal bands of sclerotisation. In the Fijian species, this feature is reduced to a single broken band but is very consistent among the six species where the female genitalia are available. Further study will be required to establish where the Fijian species fit into any available species groupings.

The wing markings show no sexual dimorphism, although the males consistently have somewhat more pointed forewings. It was therefore felt unnecessary to illustrate adults of both sexes. The markings have much in common among the species. The ground colour of the forewings varies from pale greyish yellow through to rich reddish buff; the markings are mainly whitish, sometimes with dark edging; all species have a costal stripe extending from the base to approximately four-fifths, darker towards the base; a narrow subterminal fascia widens towards the costa; basad is a costal patch from approximately three-fifths to four-fifths, extending at least half way across the wing. The shape of this patch can be diagnostic. In the hind wing a striking feature is a series of six dark, marginal eye spots between $Sc+R_1$ and Cu_{1b}; sometimes these are white-pupilled and the spots are surrounded by more or less black shading; in *E. chrysota* only four spots are present. The precise conformation of these spots shows some variation between species but in poorly marked or worn specimens considerable overlap occurs. For convenience, these spots are numbered 1 to 6 (from $Sc+R_1$ to Cu_{1b}) in the descriptions that follow.

In the male genitalia, the valves are much broader than in *Nymphicula*, being about twice as long as broad; the uncus is narrow and moderately long, but not as strikingly so as in *Nymphicula*; the aedeagus of most species contains a

striking cornutus, or group of cornuti. As these form a valuable identifying character, they are illustrated in detail here. In the female genitalia, little useful detail is shown in the area of the ostium and the sterigmata; as referred to above, the bursa copulatrix is remarkably uniform, each species having a signum in the form of an extended row of small patches; the neck of the ductus bursae shows varying areas of sclerotisation and/or swelling. This feature can be diagnostic. In the individual species descriptions, the diagnostic features noted are to be interpreted in the context of the Fijian species. All types and genitalia slides have been deposited with the National Museums of Scotland, Edinburgh.

Eoophyla hexalitha **(Meyrick, 1886), comb. n.**

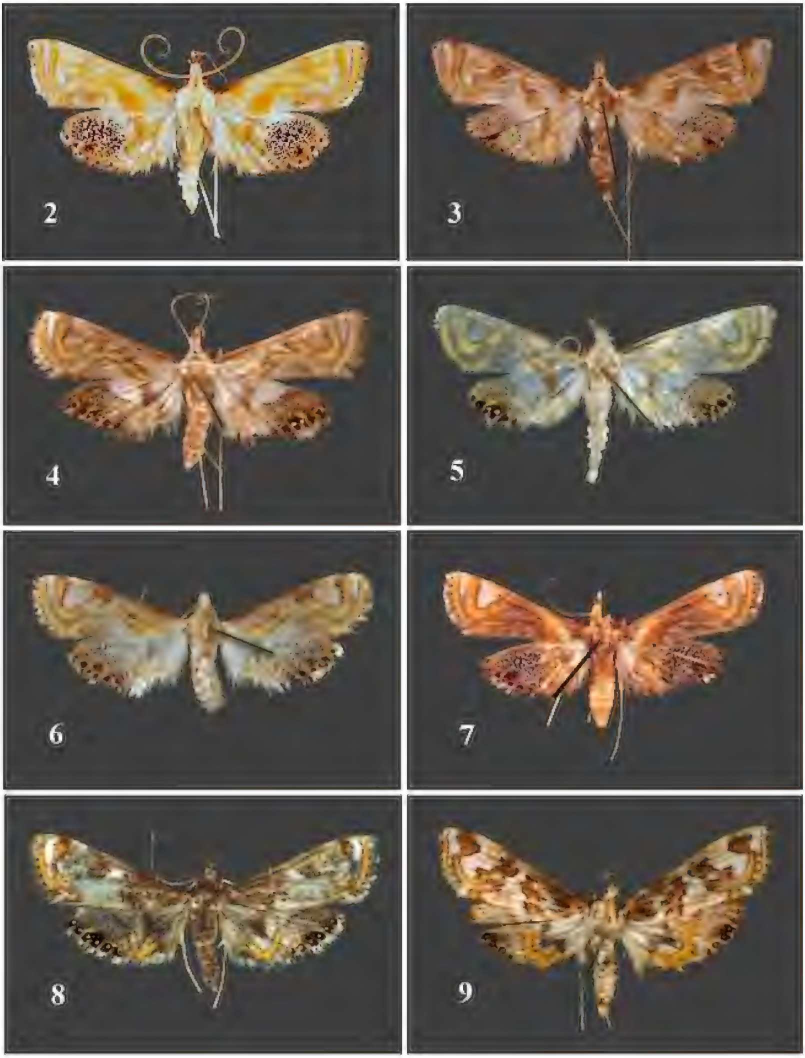
Cataclysta hexalitha Meyrick, 1886

(Figs 2, 3, 14, 21)

Redescription. Wingspan: male 18-20 mm, female 18-24 mm. This species occurs in two distinct colour forms, one with the ground colour a bright yellowish buff (Fig. 2) and the other a duller brownish buff (Fig. 3). Markings are similar in both forms, whitish, with some clouding of the ground colour. These forms occur in both sexes and the markings are similar in each case. Head, thorax and abdomen more or less of ground colour. Forewings with small basal fascia, followed by diffuse antemedial fascia from termen at one-fifth to just below costa at two-fifths confluent with discal patch; subtriangular dorsal patch from two-fifths to four-fifths extending half way across wing with scattered shading of ground colour; costal patch from three-fifths to four-fifths, extending about three-fifths across wing; costal two-thirds broad and parallel sided, dorsal third half the width due to excision of basal side; edged with blackish distad; again some scattered shading of ground colour; subterminal fascia angled near dorsum, then widening evenly to costa; edged distad and partially basad with blackish; a terminal row of fine black dots. Hind wings with six very small, well defined marginal black spots in a marginal band of the ground colour, with fine white pupils which may be obsolete in all except 3 and 4; diffuse larger black spot just inside marginal spot 4; terminal half of wing whitish speckled with black; diffuse whitish basal fascia and medial fascia merging with specked area.

Male genitalia as in Fig. 14; aedeagus with a striking group of 8 cornuti. Female genitalia as in Fig. 21; ductus bursae with clearly defined constriction a little beyond ostium followed by a sclerotised, slightly swollen section; inner boundary of this sclerotised section diffuse, outer boundary sharp. Signum a longitudinal row of about 20 small chitinous spots.

Distribution. Moderately common in lowland forest. Taken in Serua, Namosi and the Suva area.



Figs 2-9. *Eoophyla* spp: (2) *E. hexalitha* (Meyrick) ♂; (3) *E. hexalitha* (Meyrick) ♀; (4) *E. albipuncta* sp. n. ♀; (5) *E. albipuncta* sp. n. ♂; (6) *E. vitiensis* sp. n. ♀; (7) *E. lutea* sp. n. ♀; (8) *E. nephelanthopa* (Meyrick) ♀; (9) *E. montana* sp. n. ♂.

Diagnosis. Type examined. The four species *E. hexalitha, E. vitiensis, E. albipuncta* and *E. lutea* have very similar wing markings, although

E. hexalitha can usually be distinguished by its larger size. The shape of the costal patch in the forewing is diagnostic, as is the larger black spot adjacent to marginal spot 4. In the male genitalia the cornuti are a very clear diagnostic feature. In the female genitalia, the distinct constriction at the base of the ductus bursae followed by the slightly swollen sclerotised section, with the diffuse apical boundary, are also diagnostic.

Eoophyla albipuncta sp. n.

(Figs 4, 5, 15, 22)

Types. Holotype ♂, FIJI: Viti Levu, Savura Creek, -18°04′15″, 178°26′50″, 17.vii.91, at light, J.A. Clayton. *Allotype* ♀, same data as holotype except 30.vi.92. *Paratypes*: same data as holotype except Namosi Highlands, -18° 06′ 08″, 178° 10′ 30″, 3 ♂♂, 21.ix.92, 21.ix.92 and 28.ii.93, 2 ♀♀, 19.ii.12 and 28.ii.93; all J. Clayton.

Description. Wingspan: male 10-12 mm, female 11-14 mm. This species also occurs in two distinct colour forms, one with the ground colour buff (Fig. 4) and the other a much paler dull yellow (Fig 5). Markings whitish; in the darker form some brownish shading; in the lighter form with a silvery tinge and little shading, giving this form a generally washed out appearance. These forms occur in both sexes and the markings are similar in each case. Head, thorax and abdomen more or less of ground colour. Wings mostly as in *E. hexalitha*. Forewings with basal shade edged broadly dark distad; a tooth-shaped mark sloped distad from below costal stripe at one half, edged dark on both sides; triangular dorsal patch from one-third to four-fifths and broadly edged dark basad; a curved pale streak running from the apex of this mark to the tornus; a costal patch extending about half way across wing, of even shape, rounded dorsally; edged with blackish except near costa. Hind wings with somewhat larger terminal black spots; 3 and 4 larger still with clear white pupils, often coalescing; terminal two-fifths of wing whitish speckled with black; medial fascia clear white, from costa, narrowing to a point about half way across wing and with distinct sharp boundary to speckled area.

Male genitalia as in Fig. 15; aedeagus with a pair of large, almost identical, structured cornuti. Female genitalia as in Fig. 22; no constriction or swelling in ductus bursae; a narrow sclerotised submedial section with both boundaries diffuse.

Etymology. The name *albipuncta* (Latin adjective) refers to the clear white pupils in two of the hindwing marginal spots.

Distribution. Moderately common in lowland forest. Taken in Tailevu, Namosi and the Suva area.

Diagnosis. The shape of the forewing costal patch immediately separates *E. albipuncta* from *E. hexalitha* and the presence of the clear white medial fascia in the hind wing separates it from *E. lutea*. It is very similarly marked to *E. vitiensis*, from which it can best be separated by the sharply defined distal boundary of the hindwing medial fascia. However, especially with

worn examples, examination of the genitalia will be necessary to reliably separate the two. In the male genitalia the cornuti are a very clear diagnostic feature. In the female genitalia the form of the sclerotised section of the ductus bursae, with the lack of any swelling, is similar to *E. nephelanthopa*, but the diffuse basal boundary is diagnostic. Signum forming a row of about 20 small chitinous spots across the apical area of the bursa copulatrix.

***Eoophyla vitiensis* sp. n.**

(Figs 6, 16, 23)

Types. Holotype ♂, FIJI: Viti Levu, Savura Creek, -18°04′15″ 178°26′50″, 30.vi.92, at light, J.A. Clayton. *Allotype* ♀, same data as holotype except Namosi Highlands, -18°06′08″, 178°10′ 0″, 30.vi.92. *Paratypes*: same data as holotype except Namosi Highlands, -18°06′08″, 178°10′30″, ♂, 2.iv.05, 2 ♀♀, 1.iv.08 and 2.iv.05, Suva, -18°09′05″, 178°26′05″, ♂, 5.v.91; all J. Clayton.

Description. See Fig. 6. Wingspan: male 12-14 mm, female 13-16 mm. Ground colour pale buff. Head and thorax paler buff; abdomen whitish buff. Forewing markings almost identical to *E. albipuncta*. Hind wings with six moderately sized black spots in a band of ground colour; spot 1 significantly smaller than others; spots 3 and 4 with small white spot just basad, followed by a diffuse black spot spanning both; terminal two-fifths of wing whitish speckled with black; large white basal fascia and a narrow medial fascia extending half way across wing from costa; band of ground colour between this and speckled area. In poorly marked or faded specimens, the arrangement of spots cannot be distinguished from that in *E. albipuncta*.

Male genitalia as in Fig. 16; valves with angular margins, the only species under consideration exhibiting this feature; aedeagus with single, moderately sclerotised, curved cornutus. Female genitalia as in Fig. 23; a constricted, heavily sclerotised section just beyond mouth of the ductus bursae, followed by a short clear band, then a sclerotised section with a well defined outer boundary and diffuse inner boundary, followed by a somewhat expanded section. Signum a longitudinal row of about 30 small chitinous spots.

Etymology. The name *vitiensis* indicates that this species is recorded from many locations across Fiji.

Distribution. By far the most numerous of the *Eoophyla* species in Fiji. Recorded from all the lowland forest locations and also from suburban Suva. As well as the large numbers taken at light, it was observed to be very numerous by day at times of emergence. On one occasion, very large numbers were observed along the Nubukavesi Creek in Namosi Province, resting on the leaves of overhanging trees (Fig. 1) and presenting a remarkable appearance, with all facing in more or less the same direction.

Diagnosis. *Eoophyla vitiensis* is marked very similarly to *E. albipuncta* [*q.v.*], from which it can be separated by the narrow, clear white hindwing medial fascia, with a clear band of ground colour between this and the distal

speckled area. In the male genitalia the shape of the valves is diagnostic, as is the shape of the single cornutus. In the female genitalia the conformation of the sclerotised sections in the ductus bursae is diagnostic.

Eoophyla lutea sp. n.

(Figs 7, 17, 24)

Types. Holotype ♂, FIJI: Viti Levu, Nukurua, -17°55′25″, 178°30′06″, 9.iii.94, at light, J.A. Clayton. *Allotype* ♀, same data as holotype except 3.vi.95. *Paratypes*: same data as holotype except ♀, 3.vi.95, ♂, Vanua Levu, Nakula Estate, -16°25′54″, 179°54′55″, 10.ii.13; all J. Clayton.

Description. See Fig 7. Wingspan: male 12-13 mm, female 16 mm. Ground colour rich orange-buff. Head, thorax and abdomen more or less of ground colour. Wing markings somewhat similar to *E. vitiensis*. Forewings with small dark brown basal fascia followed by narrower whitish subbasal fascia; dorsal patch and markings in discal area heavily shaded greyish brown, giving the central area of the wings a much darker appearance; costal patch intermediate in shape between *E. vitiensis* and *E. hexalitha*. Hind wings with marginal spots and terminal speckled area similar to *E. vitiensis*; small whitish basal fascia and somewhat obscure medial fascia with much shading of ground colour; clear bands of ground colour either side of medial fascia.

Male genitalia as in Fig. 17; aedeagus with two striking structured cornuti, one tapering basad and one distad. Female genitalia as in Fig. 24; a pronounced, moderately sclerotised swelling just before midpoint with a diffuse boundary at both ends. Signum a longitudinal row of about 10 small chitinous spots.

Etymology. The name *lutea* (Latin, adjective) refers to the overall orange/buff colouration.

Distribution. Six specimens were taken in lowland forest – in Serua, Namosi, Cakaudrove and the Suva area.

Diagnosis. *Eoophyla lutea* is very similarly marked to *E. vitiensis* and *E. albipuncta* [*q.v.*]. The dark basal fascia in the forewing, together with the dark appearance of the medial area, is diagnostic, as is the absence of a clear whitish medial fascia in the hind wing. In fresh specimens the rich ground colour may be diagnostic but this quickly fades. In the male genitalia the cornuti are diagnostic. In the female genitalia the conformation of the swollen section and its position on the ductus bursae are diagnostic.

Eoophyla nephelanthopa (Meyrick, 1934), comb. n.

Aulacodes nephelanthopa Meyrick, 1934

(Figs 8, 18, 25)

Redescription. See Fig. 8. Wingspan: male 13-17 mm, female 15-20 mm. Ground colour orange-buff in distal half of both wings, shading to dull

brownish towards base and costa. Markings whitish, with some dull brown shading. Head, thorax and abdomen dull brownish. Forewings with clear white subquadrate discal mark; large subquadrate dorsal patch from two-fifths to four-fifths, extending half way across wing; costal patch from three-fifths to four-fifths, broad and rounded towards dorsum and extending three-fifths across wing, with considerable brownish shading and confluent with corner of dorsal patch; subterminal fascia widening from dorsum to around one half, then continuing to near costa; some brownish shading in dorsal half; more or less edged distad with brown; a terminal row of dark brownish dots. Hind wings with six moderate marginal black spots, with clear white pupils; spots 3 and 4 with additional black shading basad, causing the two to coalesce; terminal two-thirds of wing whitish, finely specked with brown; whitish medial fascia from costa extending to two-thirds across wing, angled at dorsal end leaving a clear 'V' shaped band of orange-buff ground colour; diffuse whitish basal fascia.

Male genitalia as in Fig. 18; aedeagus with a pair of long narrow, slightly curved cornuti, only moderately sclerotised. Female genitalia as in Fig. 25; very similar to *E. albipuncta* but with basal boundary of sclerotised section sharply defined. Signum a longitudinal row of about 20 small chitinous spots.

Distribution. Five specimens were taken in lowland forest – in Tailevu, Namosi, Serua and the Suva area. One specimen was taken in montane forest in Naitasiri.

Diagnosis. Type examined. The wing markings of the two species *E. nephelanthopa* and *E. montana* are somewhat distinct from the other *Eoophyla* species but superficially similar to each other. Although *E. nephelanthopa* is normally darker and duller overall, in worn specimens this may not be conclusive. The shape of the costal patch in the forewing and the 'V' shape of the orange band in the hind wing are diagnostic for *E. nephelanthopa.* In the male genitalia the cornuti are diagnostic. In the female genitalia the form of the sclerotised section of the ductus bursae, with the lack of any swelling, is similar to *E. albipuncta* but the sharply defined basal boundary is diagnostic.

Eoophyla montana sp. n.

(Figs 9, 19, 26)

Types. Holotype ♂, FIJI: Viti Levu, Monasavu, -17°43′00″, 178°01′45″, 4.v.06, at light, J.A. Clayton. *Allotype* ♀, same data as holotype except 15.xii.96. *Paratype* ♀, same data as allotype; all J. Clayton.

Description. See Fig. 9. Wingspan: male 17-21 mm, female 22-25 mm. Ground colour similar to *E. nephelanthopa* but somewhat brighter. Head, thorax and abdomen whitish grey. Forewings with irregular whitish subbasal fascia; large subtriangular dorsal patch from two-fifths to four-fifths and two-

thirds across wing, confluent with discal mark; costal patch from three-fifths to four-fifths, in the form of a broad 'S' shape and extending three-fifths across wing; subterminal fascia narrow and parallel sided with some brownish shading from tornus two-thirds of way towards costa, then widening and clear white for final third; more or less edged distad with brown. Hind wings with terminal spots similar to *E. nephelanthopa* but smaller; terminal two-thirds of wing whitish, very finely specked with pale brown; whitish medial fascia from costa to two-thirds across wing, curved round at dorsal end leaving a clear 'U' shaped band of orange-buff ground colour; diffuse whitish basal fascia.

Male genitalia are shown in Fig. 19; aedeagus with a very large, striking, heavily sclerotised and structured cornutus, over half the length of the aedeagus. Female genitalia are shown in Fig. 26; ductus bursae with large strongly sclerotised expanded section, occupying most of the exterior half; basal boundary sharply defined, but apical boundary diffuse. Signum a longitudinal row of about 12 small chitinous spots.

Etymology. The name *montana* (Latin, adjective) refers to the fact that this species was taken only in montane forest.

Distribution. Six specimens were taken, all in montane forest in Naitasiri Province. This is the only known *Eoophyla* or *Nymphicula* species in Fiji which appears to be restricted to montane forest.

Diagnosis. *Eoophyla montana* is normally brighter with more clearly defined markings than *E. nephelanthopa*, although in worn specimens this may not be conclusive. The shape of the costal patch in the forewing and the 'U' shape of the orange area on the hind wing are diagnostic for *E. montana*. In the male genitalia the cornutus is diagnostic. In the female genitalia the conformation of the large expanded and sclerotised section of the ductus bursae is diagnostic.

Eoophyla chrysota **(Meyrick, 1886), comb. n.**

Paraponyx [*sic*] *chrysota* Meyrick, 1886

(Figs 10, 20)

Redescription. See Fig. 10. Wingspan: male 14 mm, female 17-19 mm. Ground colour bright yellowish buff in terminal area of both wings, becoming light brownish buff then darker brown towards base. Markings whitish. Head light brown. Thorax yellowish buff becoming light brown posteriorly. Abdomen pale buff. Forewings with small whitish basal fascia; a diffuse dark brown spot in the discal area, preceded by a diffuse area of whitish colour; costal patch from three-fifths to four-fifths, triangular in shape and extending half way across wing; subterminal fascia whitish ending just short of dorsum, parallel to termen, of approximately equal width throughout and edged distad with a series of well defined brown dashes;

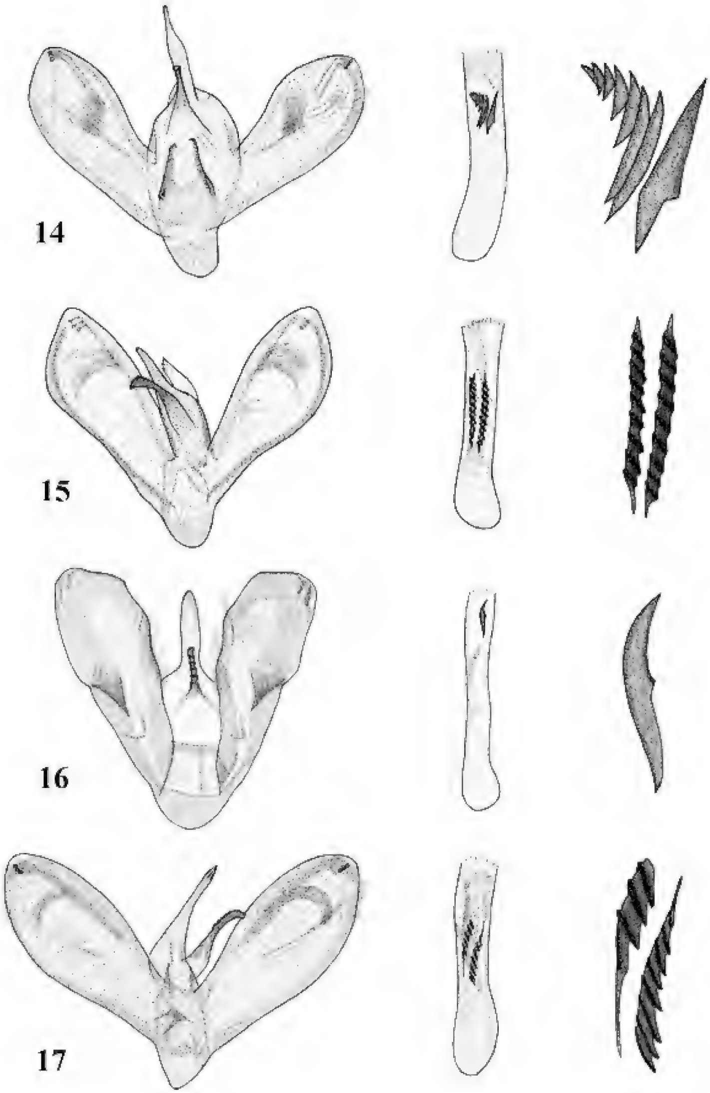
a terminal row of dark brownish dots. Hind wings with only four terminal spots; spots 1 and 2 obsolete and 3 extremely small; spots 4, 5 and 6 small, with 4 and 5 bordered basad by a small white semicircle; a narrow whitish subterminal fascia parallel to termen, partially edged distad with a fine brown line; basal two-thirds of wing clear white, with two dark brown dashes placed centrally on the distal border; very small dark brown basal fascia.

Male genitalia as in Fig. 20; aedeagus narrow, with a single long, narrow cornutus which is only lightly sclerotised. Female genitalia not examined, as the two female specimens available have damaged abdomens.

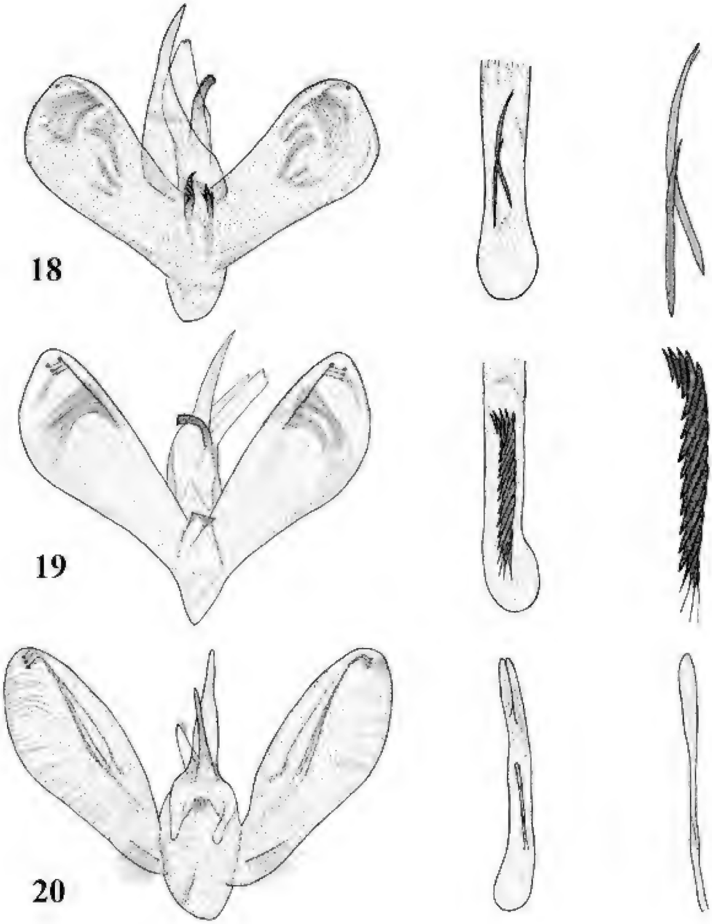
Distribution. Found to be the scarcest of the *Eoophyla* species in Fiji. Three specimens were taken – in Serua, Cakaudrove and the Suva area.

Diagnosis. Type not located. Meyrick's original detailed description (from Fiji) provides a confident identification for this well-marked species, the wing markings making it unmistakable among Fijian *Eoophyla* spp. Specifically the absence of a dorsal patch in the forewing is diagnostic. In the hind wing, the reduced number of spots and the clear white and yellowish buff colouration, with the two central brown dashes, are diagnostic. In the male genitalia the narrow aedeagus with the long, narrow, straight and lightly sclerotised cornutus is also diagnostic.

Figs 10-13. *Eoophyla* and *Nymphicula* spp: (10) *Eoophyla chrysota* (Meyrick) ♀; (11) *Nymphicula australis* (Felder & Rogenhofer) ♂; (12) *Nymphicula cyanolitha* ♀; (13) *Nymphicula* sp. ♂.



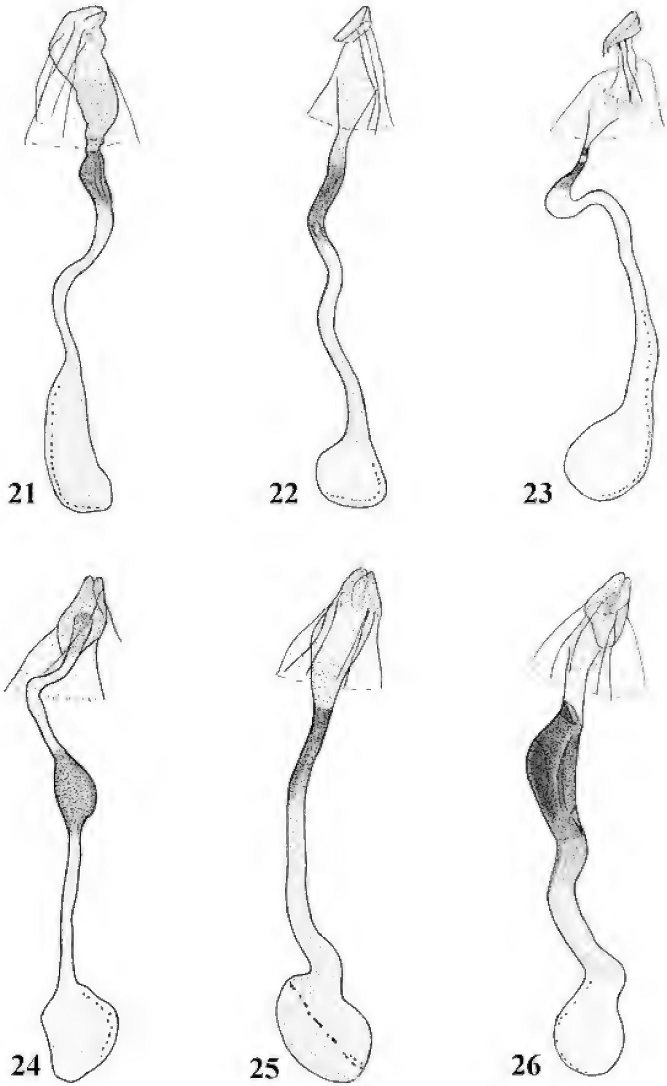
Figs 14-17. Male genitalia; aedeagus; detail of cornuti of *Eoophyla* spp: (14) *E. hexalitha* (Meyrick); (15) *E. albipuncta* sp. n.; (16) *E. vitiensis* sp. n.; (17) *E. lutea* sp. n.



Figs 18-20. Male genitalia; aedeagus; detail of cornuti of *Eoophyla* spp: (18) *E. nephelanthopa* (Meyrick); (19) *E. montana* sp. n.; (20) *E. chrysota* (Meyrick).

Genus *Nymphicula* Snellen, 1882

Speidel (1984) listed the defining characteristics of the genus as the absence of M_1 in the hind wing, tufts between abdominal segments 7 and 8 in the male, a specialised scale tuft on the eighth abdominal sternite in the male and the greatly extended uncus in the male genitalia. Agassiz (2014) confirmed this and stated that the definition had only to be slightly extended.



Figs 21-26. Female genitalia of *Eoophyla* spp: (21) *E. hexalitha* (Meyrick); (22) *E. albipuncta* sp. n.; (23) *E. vitiensis* sp. n.; (24) *E. lutea* sp. n.; (25) *E. nephelanthopa* (Meyrick); (26) *E. montana* sp. n.

Nymphicula australis **(Felder & Rogenhofer, 1874)**

Margarosticha australis Felder & Rogenhofer, 1874

(Fig. 11)

Description and diagnosis. See Fig. 11. Fully discussed and illustrated by Agassiz (1984).

Distribution. Four specimens were taken – in Tailevu, Namosi and the Suva area.

Nymphicula cyanolitha **(Meyrick, 1886)**

Anydraula cyanolitha Meyrick, 1886

(Fig. 12)

Description and diagnosis. See Fig. 12. Fully discussed and illustrated by Agassiz (1984).

Distribution. Six specimens were taken – in Namosi, Tailevu, Serua and the Suva area.

Nymphicula **sp.**

(Fig. 13)

Generic placement. A single male (Fig. 13) was taken. As the specimen is missing the abdomen, it cannot be fully described and named here. It is provisionally placed in *Nymphicula* based on the absence of M_1 in the hind wing and its similarity in wing shape and markings.

Description. See Fig. 13. For consistency, the terminology considered most suitable for the description of the *Eoophyla* species is used here also. For ease of comparison, the terminology used by Agassiz (1984) is included in brackets where this may be helpful. Wingspan male 10 mm. Ground colour bright yellow. Body pale brown. Forewings with costal streak dark brown in basal half continuing to four-fifths as pale yellow and widening somewhat; basal fascia (base) dark brown; dark brown dorsal patch (medial area) from two-fifths to four-fifths, extending two-thirds across wing; space between patch and costal streak filled continuously with dark brown; tornal spot large and dark brown; costal patch (first strigula) from three-fifths to four-fifths, from costal streak to half way across wing, with rounded apex; clear white edged dark brown; subterminal fascia (second strigula) clear white, from two-thirds across wing widening to costa and edged dark brown basad and partially distad; cilia pale with brown base.

Hind wings with six marginal black spots; white pupils scarcely visible and surrounded with dark shading causing the spots to coalesce; terminal three-fifths of wing shaded rich dark brown, confluent with shading around marginal spots; clear white costal streak to one half; clear white subbasal fascia and small brown basal fascia.

Distribution. The single specimen was taken in Namosi.

Diagnosis. The striking combination of clear white and rich dark brown markings with the bright yellow ground colour serves to distinguish this species from other Fijian *Nymphicula* species. Specifically in the forewings the short and broad costal patch (first strigula) is diagnostic, as is the overall dark appearance of the terminal three-fifths of the hind wing.

Acknowledgements

I am indebted to Dr David Agassiz of the Natural History Museum, London for helpful discussions and facilitating access to the Museum's collections. I would also like to thank Dr Keith Bland of the National Museums of Scotland for helpful discussions and advice and for arranging access to the entomological collections and other facilities at the Museum and Dr Albert Orr for helpful comments on the manuscript. Also to staff of the School of Biological, Chemical & Environmental Sciences, the University of the South Pacific, Suva, Fiji, for providing access to facilities at the University.

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MIGRATION RECORDS OF BUTTERFLIES (LEPIDOPTERA: PAPILIONIDAE, HESPERIIDAE, PIERIDAE, NYMPHALIDAE) IN THE 'TOP END' OF THE NORTHERN TERRITORY

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Abstract

New records of butterfly migration in the 'Top End' of the Northern Territory concerning six species, *viz*: *Papilio demoleus* Linnaeus, 1758 (Papilionidae), *Badamia exclamationis* (Fabricius, 1775) (Hesperiidae), *Catopsilia scylla* (Linnaeus, 1763), *Eurema hecabe* (Linnaeus, 1758), *Belenois java* (Linnaeus, 1768) (Pieridae) and *Junonia hedonia* (Linnaeus, 1764) (Nymphalidae), are presented based on data accumulated over the period 2005-2015. In four species for which multiple records were obtained over different years, patterns of migration were remarkably consistent in terms of flight direction and season, with predominantly northerly movements in September-October (*B. java*), January-April (*B. exclamationis*) and April-May (*C. scylla* and *J. hedonia*).

Introduction

Migration, the purposeful movement of individuals in one general direction over a large area relative to the geographical range of the species, is a fundamental component of the life history strategy of butterflies that track seasonal changes in resources (*e.g.* larval food plants, breeding habitats) or aggregate in non-breeding (*e.g.* overwintering) sites (Dingle 1996). Smithers (1978, 1983a, 1983b, 1985) provided a comprehensive review and presented a substantial amount of new data on the species that are known or suspected to be regular migrants in Australia. Dingle *et al.* (1999, 2000) subsequently analysed this dataset, which also included additional records gleaned from the literature, to determine if there were general consistent patterns in both timing and direction, and examined possible ecological factors accounting for seasonal shifts in geographical range. For eastern Australia, where most migration data of butterflies has been assembled, they found that latitude, rainfall patterns and soil moisture were the main determinants.

However, Dingle *et al.* (1999) noted that for a number of migratory butterflies in Australia, such as *Papilio demoleus* Linnaeus, 1758, too few observations were available to draw general conclusions on orientation and seasonal timing of migration and called for more data on these species. Moreover, comparatively little data are available for the monsoon tropics of northwestern Australia. Smithers and McArtney (1970) recorded hundreds of specimens of *P. demoleus sthenelus* W.S. Macleay, 1826 flying south-east over a distance of 25 km across the Stuart Highway between Elliott and Renner Springs, NT, in May 1969. Grund and Hunt (2001) noted adults of *Elodina padusa* (Hewitson, 1853) migrating in large numbers in a southerly direction on the Mitchell Plateau in the Kimberley, WA, sometime between late June and mid July 2000. Braby (2014) documented a temporary range

expansion of *Danaus plexippus* (Linnaeus, 1758) in the western Gulf Country (northwestern Qld-NT) and central Australia (NT), in which small numbers were observed flying north, north-west or west during May 2013. He also summarised records of *Catopsilia pyranthe crokera* (W.S. Macleay, 1826) in the Darwin area and from nearby locations, a region in which the species is normally absent, and concluded that the species is a rare seasonal immigrant to the northern coastal parts of the 'Top End', with influxes likely to occur in March-April and less frequently during June-August and in December.

Here, I present new data on movements concerning six species of butterflies, based on records from the 'Top End' of the Northern Territory. Of particular interest are the first records of *Catopsilia scylla etesia* (Hewitson, 1867) and *Junonia hedonia zelima* (Fabricius, 1775) as migrants in Australia.

Methods

Observations on butterfly movement in the 'Top End' of the Northern Territory were made opportunistically over a 10-year period during 2005-2015. Most observations were made between Darwin and Katherine but some were further afield. Most observations were qualitative but on eight occasions attempts were made to quantify the adult density of the migration; this was done by counting the number of individuals crossing a transect of defined length over a short period of time. There are currently no standardised protocols in Australia for quantifying butterfly migrations in terms of time (number of minutes and time of day), space (transect length) and number of repeat samples needed to estimate the arithmetic mean and variance around the mean. In this paper, the time period during which butterflies were counted varied from 9-45 mins (average 18 mins) and counts were conducted on still, sunny days, mainly around midday from 1145-1330 h, although one count was made during the morning from 0950-1000 h. The length of the transects over which butterflies traversed varied from 10-50 m but was usually 20-50 m. Repeated counts were not made to estimate the mean and standard deviation of the numbers migrating. The migration rate or density was then subjectively classified into one of four class-intervals irrespective of transect length: small (<1 adult per minute), moderate (1 adult per minute), large (1-10 adults per minute) and very large (>10 adults per minute).

Observations

PAPILIONIDAE

Papilio demoleus Linnaeus, 1758, Chequered Swallowtail

A large-scale movement of this species was observed in February 2015, the only migration recorded over the 10-year period (Table 1). The migration lasted for just under two weeks and appeared to peak around 4-5 February. Adults were mostly in fresh condition and flew rapidly within 3 m of the ground, between mid morning and mid afternoon. The flight extended over a relatively large area, with records from offshore areas of Cobourg Peninsula,

Table 1. Migration and associated records for *Papilio demoleus* in the Northern Territory.

Location	Date	Observer	Direction	Comments
Wanguri, Darwin, NT (12.37308°S, 130.88657°E)	2 Feb. 2015	M.F. Braby	ESE	Small numbers flying rapidly around midday.
Darwin northern suburbs (Bullocky Point-Wanguri), NT	3 Feb. 2015	M.F. Braby	ESE	Large numbers flying rapidly between 0900-1300 h. Many adults captured were freshly emerged, but others were worn.
Bees Creek, NT (12°34'S, 131°03'E)	4 Feb. 2015	G. Ainsworth		Influx of adults recorded on rural block, not previously recorded during past 12 years.
Wanguri, Darwin, NT (12.37308°S, 130.88657°E)	4-5 Feb. 2015	M.F. Braby	E (NE-SE)	Very large numbers flying rapidly, mainly E, from 0830 h to mid to late afternoon.
Darwin eastern suburbs (Wanguri-Palmerston), NT	6 Feb. 2015	M.F. Braby	E (ESE-SE)	Small numbers flying rapidly, mainly E.
Holmes Jungle CP, Darwin, NT (12°24'S, 130°55'E)	6 Feb. 2015	T. Ratnayeke		Influx of many adults observed at Holmes Jungle and Karama; mostly freshly emerged.
Mt Burrell, Tipperary Station, NT (13.49623°S, 131.03572°E)	7 Feb. 2015	M.F. Braby	SSW	Large numbers flying between 0930-1130 h.
6 km NW of Robin Falls, NT (13.34119°S, 131.11801°E)	7 Feb. 2015	M.F. Braby	SSW	Moderate numbers flying rapidly from midday to mid afternoon (1/min/50m: 1305-1315 h).
Cobourg Peninsula, NT	8 Feb. 2015	A. Withers	W	Many adults flying over ocean 10 nautical miles offshore.
Darwin northern suburbs (CBD-Wanguri), NT	8-10 Feb. 2015	M.F. Braby	S (SSW-SW)	Small numbers flying rapidly, mainly S, between 0830-1000 h.
Humpty Doo, NT (12°34'S, 131°06'E)	10 Feb. 2015	D. Binns		Influx of many adults observed in rural area, as well as suburbs of Darwin.
Wanguri, Darwin, NT (12.37308°S, 130.88657°E)	11-12 Feb. 2015	M.F. Braby	S or W	Small numbers flying rapidly (0.1/min/50m: 1300-1330 h).
6.5 km N of Berry Springs, NT (12.64514°S, 131.00986°E)	14 Feb. 2015	M.F. Braby	W	Few adults flying between 1200-1330 h.

Darwin suburban and rural areas and the Mt Burrell-Robin Falls area to the south-west of Adelaide River. Curiously, the direction of flight shifted progressively from an easterly, through southerly to finally a westerly direction during the course of the migration period. At Darwin, for example, adults flew predominantly east near the start of the migration (3-5 February), when immense numbers of butterflies were observed flying rapidly across suburban streets, parks and gardens, rarely pausing to stop to feed from flowers; however, towards the end of the migration (8-12 February) they flew mainly south or west and in considerably lower numbers.

HESPERIIDAE

Badamia exclamationis (Fabricius, 1775), Narrow-winged Awl

Small to moderate numbers of this species were recorded migrating on four separate occasions (in different years) between late January and early April, particularly in March and early April (Table 2). In general, adults flew rapidly 3-5 m or more above ground in a northerly direction (with the direction of flight varying from NW, NNE to ENE) between mid morning and early afternoon. The only exception to this general pattern was a southerly flight (SSW) recorded in late January 2011. However, despite careful surveillance during subsequent days at this site no further adults were detected flying south in January.

PIERIDAE

Catopsilia scylla (Linnaeus, 1763), Orange Migrant

Observations on directional flight of this species were made on three separate occasions (in different years) in the more inland areas (Table 3). In general, small to moderate numbers were observed flying rapidly in a northeasterly direction (with the direction of flight varying from N, NE to E) between mid April and early May. No quantitative estimates were made on adult density or time of day.

Eurema hecabe (Linnaeus, 1758), Large Grass-yellow

Only one record of migration was made for this species, in April 2015, when large numbers were observed flying east during early afternoon (Table 3). They flew very close to the ground, within about 1 m.

Belenois java (Linnaeus, 1768), Caper White

Migration of this species in the Darwin area was observed on four separate occasions (in different years) between late September and mid October during the early afternoon (Table 3). In general, adults flew in a north to northwesterly direction and generally small numbers were involved but, in 2009, a substantial flight involving moderate numbers of adults that lasted for four days was observed. On three of these occasions (2005, 2007, 2009) the migrations were associated with subsequent breeding, in which considerable numbers of immature stages (eggs, larvae and pupae), as well as adults, were

detected on the larval food plants, namely the vine *Capparis sepiaria* (Capparaceae) growing in nearby coastal monsoon vine thicket, or cultivated trees of *C. umbonata* in suburban parks and nature strips. The breeding often continued for several months (up until December or January), during which several overlapping generations were completed.

Table 2. Migration records for *Badamia exclamationis* in the Northern Territory.

Location	Date	Observer	Direction	Comments
Rapid Creek, Darwin, NT (12.38083°S, 130.86462°E)	8 Mar. 2008	M.F. Braby & D.C. Franklin	ENE	Moderate numbers flying rapidly during morning (1/min/30m: 0950-1000 h).
Leanyer Sewage Ponds, Darwin, NT (12°21'S, 130°54'E)	8 Mar. 2008	M.F. Braby & D.C. Franklin	ENE	Small numbers flying rapidly at 1100 h.
30 km SE of Pine Creek, NT (14.06290°S, 131.97026°E)	15 Mar. 2008	M.F. Braby	N–NNE	Moderate numbers flying rapidly across Stuart Hwy during late morning (1/min/20m: 1145-1200 h).
Bullocky Point, Darwin, NT (12.43777°S, 130.83377°E)	27 Jan. 2011	M.F. Braby	SSW	Moderate numbers flying rapidly during midday (1/min/30m: 1200-1245 h).
Dundee Beach, NT (12.76420°S, 130.35324°E)	1 Apr. 2012	M.F. Braby	NNE	Small numbers flying rapidly between 1000-1100 h.
Parap, Darwin, NT (12°26'S, 130°50'E)	5 Apr. 2012	M.F. Braby	NE	Small numbers flying rapidly during early afternoon (0.3/min/10m: 1300-1310 h).
Holmes Jungle CP, NT (12°24'S, 130°55'E)	31 Jan. 2015	M.F. Braby	NW	Small numbers flying rapidly between 1030-1130 h.
Wanguri, Darwin, NT (12.37308°S, 130.88657°E)	1 Feb. 2015	M.F. Braby	NW	Small numbers flying rapidly between 1000-1030 h.

NYMPHALIDAE

Junonia hedonia (Linnaeus, 1764), Chocolate Argus

Migration of this species was observed on four separate occasions (in different years) in the more inland areas (Table 4). In general, small to moderate numbers of adults flew rapidly 2-3 m above the ground in a northerly direction (with the direction of flight varying from N, NNE to NE)

between mid April and early May, from late morning to early afternoon. In 2012, a series of observations were made over a 13-day period between 22 April and 4 May, in which large numbers of adults were recorded, indicating that migration lasted for approximately two weeks.

Table 3. Migration records for *Catopsilia scylla, Eurema hecabe* and *Belenois java* in the Northern Territory.

Location	Date	Observer	Direction	Comments
		Catopsilia scylla		
1.6 km NNW of Pine Creek, NT (13.80997°S, 131.82852°E)	1 May 2010	M.F. Braby & L.J. Aitchison	N	Small numbers flying rapidly around midday.
Dunmarra–50 km SSE of Elliott, NT	7 May 2013	M.F. Braby	E	Very small numbers flying rapidly across Stuart Hwy over a distance of *c.* 150 km.
Katherine Gorge campground, Nitmiluk NP, NT (14.31803°S, 132.42026°E)	15 Apr. 2014	M.F. Braby & L.J. Aitchison	NE	Moderate numbers flying rapidly.
		Eurema hecabe		
Noonamah-Adelaide River, NT	3 Apr. 2015	M.F. Braby & L.J. Aitchison	E	Large numbers flying across Stuart Hwy during early afternoon over a distance of *c.* 70 km (4.9/min/50m: 1321-1330 h).
		Belenois java		
Darwin CBD, NT (12°27'S, 130°50'E)	17 Oct. 2005	M.F. Braby	NW	Small numbers flying during early afternoon.
CSIRO complex Berrimah, Darwin, NT (12°24'48"S, 130°55'19"E)	3 Oct. 2007	M.F. Braby	NW	Small numbers flying rapidly at 1240 h.
Wanguri, Darwin, NT (12.37308°S, 130.88657°E)	12 Oct. 2008	M.F. Braby	N	Small numbers flying rapidly at 1250 h.
Wanguri, Darwin, NT (12.37308°S, 130.88657°E)	29 Sep. 2009	M.F. Braby	NNW	Moderate numbers flying rapidly during early afternoon between 1200-1500 h) (1/min/ 10m: 1215-1230 h). Migration continued for next three days but in substantially smaller numbers and ceased by 3 Oct. 2009.

Table 4. Migration records for *Junonia hedonia* in the Northern Territory.

Location	Date	Observer	Direction	Comments
1.6 km NNW of Pine Creek, NT (13.80997°S, 131.82852°E)	1 May 2010	M.F. Braby & L.J. Aitchison	N	Small numbers flying rapidly.
Wanguri, Darwin, NT (12.37308°S, 130.88657°E)	2 May 2010	M.F. Braby	N	One flying very rapidly during early afternoon.
1.6 km NNW of Pine Creek, NT (13.80997°S, 131.82852°E)	8 May 2010	M.F. Braby & S. Keates	N	Small numbers flying rapidly during late morning.
Adelaide River-Douglas Daly Research Farm, NT	22 Apr. 2012	M.F. Braby	NNE	Large numbers flying rapidly over a distance of *c.* 100 km between 1200-1430 h.
Mt Muriel, Fish River Station, 7 km SSW of Douglas Daly Research Farm, NT (13.89433°S, 131.15822°E)	23 Apr. 2012	M.F. Braby	NE	Large numbers flying rapidly between 1200-1400 h.
Fish River Station, 6 km S of Daly River (Nauiyu), NT (13.80356°S, 130.69644°E)	27 Apr. 2012	M.F. Braby	NE	Small numbers flying between 1230–1330 h.
Noonamah-Acacia, NT	4 May 2012	M.F. Braby	NE	Large numbers flying rapidly across Stuart Hwy over a distance of *c.* 20 km between 1115-1130 h.
Adelaide River-Pine Creek, NT	6 May 2013	M.F. Braby	N	Large numbers flying across Stuart Hwy over a distance of *c.* 100 km during early afternoon.
Marrakai Rd, 2.5 km E of Stuart Hwy, NT (12.90468°S, 131.16080°E)	19 Apr 2015	M.F. Braby & D. Bisa	N	Small numbers flying rapidly between 1130–1300 h.

Discussion

Of the six species reported here as displaying migratory behaviour in the Northern Territory, four (*Papilio demoleus, Badamia exclamationis, Eurema hecabe* and *Belenois java*) are well-known migrants elsewhere in Australia (see Smithers 1978, 1983a, 1983b, 1985, Dingle *et al.* 1999) but, for the two other species (*Catopsilia scylla* and *Junonia hedonia*), there appear to be no previous records of migration in Australia. Interestingly, for the four species for which multiple records were obtained over different years (*B. exclamationis*, *C. scylla*, *B. java* and *J. hedonia*), the patterns of migration were remarkably consistent both in terms of direction of flight and time of year. Thus, all these species were observed flying in a predominantly northerly direction, with *B. java* in September-October, *B. exclamationis* mainly in March-April, and *C. scylla* and *J. hedonia* in April-May. This suggests that seasonal movement in these species is a regular component of their life history in northwestern Australia.

With the exception of *B. java*, the significance of migration in this set of species remains to be determined. *Belenois java* was the only species for which migration was clearly associated with breeding. My long-term observations at Darwin indicated that the species usually appeared each year during the 'build-up' and early wet season (*i.e.* September-December), but it was generally absent during the rest of the year. Similarly, Meyer *et al.* (2006) recorded this species in the Darwin area only in September. However, in 2010 an influx of the species was recorded in late March that was followed by breeding, with immature stages comprising numerous clusters of eggs and first instar larvae being detected on *Capparis sepiaria* at Bullocky Point; however, the direction of flight on this occasion was not apparent. Interestingly, Dingle *et al.* (1999) commented that all reports of directional flight for *B. java* in Australia were in 'spring' and that migrations in northeastern Australia (Qld) were predominantly north or east, in contrast with those in southern Australia (NSW, Vic) which were south or west. These findings are consistent with those in the NT, suggesting that northerly migrations in northwestern Australia may be characteristic of this species.

Movement in *B. exclamationis* may also be associated with colonisation of breeding habitats, similar to that reported in Queensland (Burns 1933, Smithers 1978, Valentine 2004). However, the breeding habitat/range of this species is not well understood in northwestern Australia. The only documented breeding record is from the lower rainfall areas of the eastern Kimberley where the immature stages of *B. exclamationis* were found on *Terminalia microcarpa* (Combretaceae), which grew in abundance in riparian monsoon vine thicket at Black Rock Falls track near Kununurra, WA, in December (Meyer 1996 and pers. comm.). Kununurra is located approximately 430 km SSW of Darwin and, moreover, this was the same direction of flight observed at Darwin in late January 2011. Thus, the

southerly flight recorded in January at Darwin might have been the arrival of an immigrant population (possibly originating from mainland New Guinea) dispersing to the breeding areas in the eastern Kimberley; the northerly flights recorded in January-April (particularly in March-April) might well comprise a return flight of the next generation. The timing of these migrations probably vary with the season and start of the monsoon and further observations are needed to establish if there are regular southward migratory flights earlier in the season, in October-December. Smithers (1978) reported considerable variation in the timing of movements for the species in Queensland, particularly the southbound flight.

Migration in both *J. hedonia* and *C. scylla* consistently occurred at the end of the wet season but the reason for such population movements was not established. Presumably, adults disperse from the more inland areas to exploit breeding habitats in the coastal or near coastal areas of the 'Top End' that only become available at the start of the dry season. For example, *J. hedonia* breeds in floodplain wetlands (on the annual herb *Hygrophylla angustifiolia* in paperbark swamps), which are typically inundated during the wet season. It is likely that the larval food plant grows rapidly during this period so that by the start of the dry season the plants have copious foliage that is ready to be exploited by *J. hedonia* larvae.

In the case of *C. scylla*, Braby (2000) speculated that it was migratory based on its seasonal appearance over much of its range, but noted that no details on adult movements in Australia had been published. Moreover, there are no confirmed reports of migration of the species in South-East Asia (Yata 1985, van der Poorten and van der Poorten 2012), despite its common name 'Orange Migrant' or 'Orange Emigrant'. At Darwin, breeding was noted to be seasonal, with the immature stages (eggs and larvae) usually recorded around March-May and again in September-November (on *Senna surattensis* in monsoon vine thicket or suburban gardens). Similarly, Meyer *et al.* (2006) noted that *C. scylla* was seasonal in Darwin, with adults recorded only during March-May. Its regular seasonal appearance in Darwin suggests the arrival of migratory populations at the end of the wet season.

Acknowledgements

I thank C.E. Meyer for breeding data on *Badamia exclamationis* and G. Ainsworth, L.J. Aitchison, D. Binns, D. Bisa, D.C. Franklin, T. Ratnayeke, S. Keates and A. Withers for observation records or field assistance. M.R. Williams, D.C. Franklin, P.S. Valentine and A.G. Orr kindly read and improved a draft of the manuscript.

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AN UNDESCRIBED CONCEALER MOTH, *STATHMOPODA* SP. (LEPIDOPTERA: OECOPHORIDAE) IN NESTS OF THE WEAVER ANT *POLYRHACHIS AUSTRALIS* MAYR (HYMENOPTERA: FORMICIDAE)

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Abstract

A concealer moth, genus *Stathmopoda* Herrich-Schäffer, 1853, closely resembling one known from Hervey Bay, Queensland and Coonabarabran, New South Wales but as yet undescribed, was found in nests of the weaver ant *Polyrhachis australis* Mayr, 1870 in Townsville, Queensland. The weaver ant nests provide the moth larvae with shelter and perhaps food in the form of dead leaves and/or the brood of the host ants. What deters the ants from attacking the moth larvae is unknown, as is the mechanism allowing the eclosed adult moths to exit the ants' nests unharmed.

Introduction

Concealer moths, family Oecophoridae, are named for the tendency of the larvae to 'hide' in silk shelters, often in the curls of rolled foliage. Unsurprisingly, what is known about the biology of the Australian fauna is limited and fragmentary but, while their feeding habits centre in the main on plant (especially dead plant) material, a number of records exist of these moths exploiting the adults and brood of other arthropods (Common 1990). The taxonomy, meanwhile, saw its last revision 70 to 80 years ago (Turner 1932-1947), with no realistic prospect of another in the foreseeable future; hence many specimens, including the one documented here, await a specific description and a name.

Discussion

Eight adults of the undescribed concealer moth were reared from pupae collected in Cranbrook, Townsville (19.30ºS, 146.75ºE), the first in June 2013 and the eighth in April 2014. Three originated from a clump of rotting plant debris wedged in a palm thicket (Fig. 1). Five others came from within two nests of the weaver ant *Polyrhachis australis* Mayr, 1870, a colony of which had long been established among these palms and the surrounding vegetation (Fig. 2). A ninth adult moth came from a *P. australis* nest collected in Mundingburra, Townsville (19.30ºS, 146.79ºE).

In these weaver ant nests, the moth larvae sheltered in narrow silk tunnels aligned along one of the nest margins, typically where the edge of a living or dead supporting leaf was curled along its long axis.

In all but one of the nine cases, larvae were present in addition to the pupae that produced adults. Because other moth species occurred in the same habitat, no unequivocal full sequence of larval instars, pupa and adult was established. However, over a five year period of investigation of more than

400 nests of *P. australis* at this location (Downes 2015), more than 30 matching larvae (Figs 3-4) and more than 40 matching pupae (Figs 5-6) were observed and/or collected from 23 nests, covering all months except May.

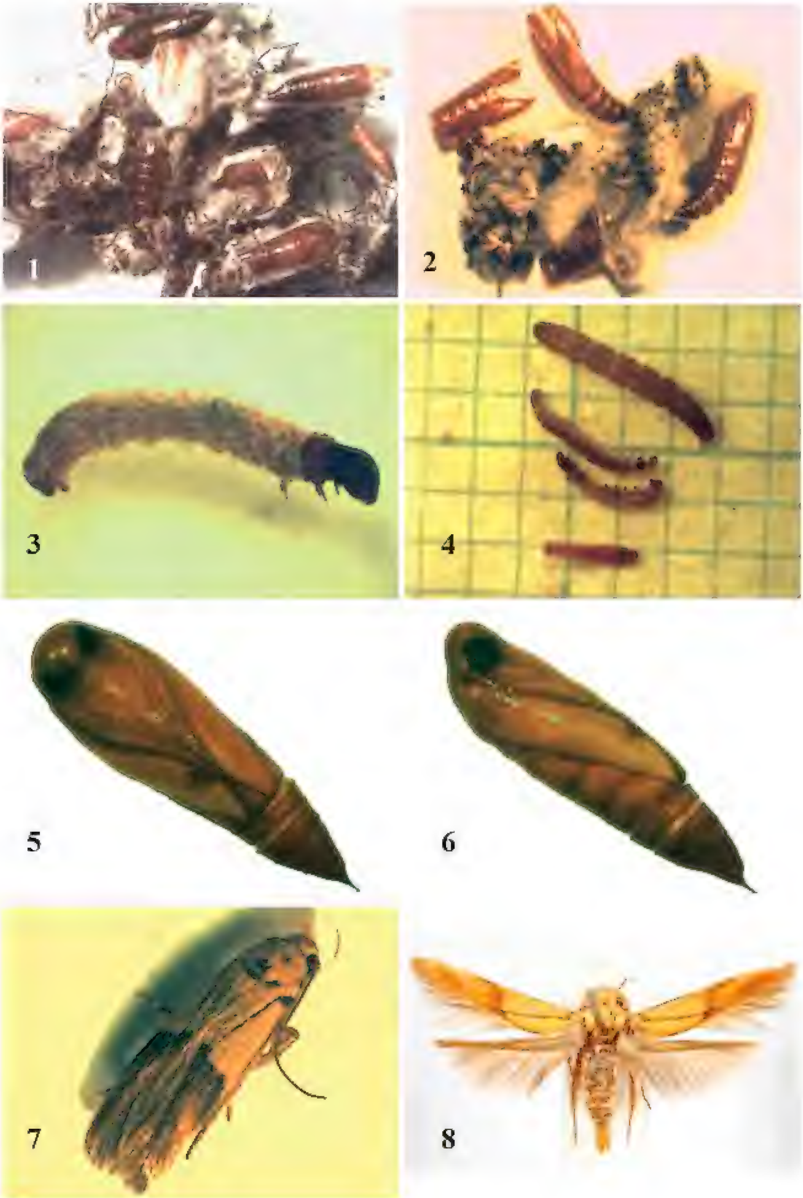
Sometimes the larvae most suspected of being those of the concealer moth occurred together with empty pupal cases of the adult. Larvae smaller than the suspected second instar illustrated in Fig. 3 were observed among the ants' eggs on one occasion, but whether these were first instar larvae of this moth cannot reliably be gauged. The material available suggests a sequence of four larval instars that carry out their feeding tasks and complete their development in the presence of the ants. How they accomplish this is unknown, as is the mechanism that allows the eclosed adult moth to depart the nest unharmed. Some adult butterflies, *e.g. Liphyra brassolis* Westwood, escape from inside the nests of aggressive host ants by shedding wing and body scales (Dodd 1902) but this tactic is unlikely to apply in this case.

The smooth body scales of the adults (Figs 7-8) give the moth a shiny gold hue. The wings are golden yellow anteriorly and dark to black posteriorly, heavily fringed along their trailing edges. They were found to closely resemble (but not match identically) undescribed specimens of the genus *Stathmopoda* Herrich-Schäffer, 1853, now in the Australian National Insect Collection, which were obtained by Ian Common at Pialba (Hervey Bay), Queensland and Coonabarabran, New South Wales, the former reared from dead leaf litter and the latter collected at light.

It could be inferred from this that the larvae feed on dead plant material, as do the majority of oecophorids (Common 1990); this could also apply to the larvae developing in the weaver ant nests. Alternatively, or in addition, the larvae could be preying on the ants' brood. It would not be the first gelechioid moth to be found to subsist on arthropod brood (Austin 1977), nor the first *Stathmopoda* sp. to do so (Downes 1994), nor even the first moth predatory on ant larvae (Narukawa *et al.* 2002).

The circumstances under which specimens were obtained, especially the extraction of larvae and pupae from rotting plant matter, all but preclude an obligate association of the moth with the weaver ants but, in this connection, it is worth noting that the clump of decomposing plant substance had a bivouac of ants, *Technomyrmex* sp., at its core. Voucher specimens (three adult moths) have been deposited in the Australian National Insect Collection, Canberra.

Figs 1-8. (1-2) Moth pupal cases and their silk shelters: (1) among plant debris; (2) among silk and carton of one of the weaver ant nests. (3-4) Moth larvae and pupae: (3) larva believed to be the second instar of the concealer moth, x15; (4) suspected second (lower), third (middle) and fourth (upper) instar larvae, x3. (5-6) Moth pupae: (5) ventral aspect of pupa, x10; (6) lateral aspect of pupa, x10. (7-8) Reared adult moths: (7) dorsolateral aspect before setting, x8; (8) set and spread, x7.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Acknowledgements

Len Willan alerted MD to the article by Junko Narukawa and colleagues. Shigehiko Shiyake, website manager of the Coleopterological Society of Japan, kindly provided a copy of the article. You Ning Su took the photograph of the set adult moth. Malcolm Tattersall readily gave access to his garden for collecting weaver ant nests. Grateful thanks are extended to all four for their assistance.

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ACACIA MELVILLEI PEDLEY (MIMOSACEAE), A NEWLY-RECORDED LARVAL FOOD PLANT FOR *JALMENUS EUBULUS* MISKIN (LEPIDOPTERA: LYCAENIDAE)

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Abstract

Larvae of *Jalmenus eubulus* Miskin, 1876, have until recently, been considered monophagous, feeding exclusively on Brigalow, *Acacia harpophylla* F. Muell. Ex Benth., unlike the closely-related and oligophagous *J. evagoras* (Donovan, 1805). Here we record a second food plant for *J. eubulus,* Yarran, *Acacia melvillei* Pedley. The solitary larvae feed on understory growth of *A. melvillei* and the adults occur in a habitat dominated by *A. melvillei*. It is recommended that the threatened conservation status of *J. eubulus* be retained.

Introduction

Jalmenus eubulus Miskin, 1876, was originally described as a distinct species but Waterhouse and Lyell (1914) considered it to be a northern, inland subspecies of *J. evagoras* (Donovan, 1805). Eastwood *et al.* (2008) returned *J. eubulus* to species rank and based differences in the two species on adult morphology, ecology, DNA, food plant and habitat. They also provided a review of synonymy and the type material of *J. eubulus*.

Whereas *J. evagoras* is distributed widely in the coastal and lower mountain regions of Victoria and eastern New South Wales and the coastal and subcoastal regions of southeastern Queensland (Waterhouse and Lyell 1914, Waterhouse 1932, Dunn and Dunn 1991, Braby 2000), *J. eubulus* occurs in a limited area of the dryer, inland brigalow belt in far northern New South Wales (Taylor 2014) and southern Queensland (Dunn and Dunn 1991, Orr and Kitching 2010, Eastwood *et al.* 2008, Braby and Williams 2016).

Jalmenus eubulus shows little variation in adult morphology throughout its range (Dunn and Dunn 1991), unlike the geographically variable *J. evagoras*, where adults of several northern and northwestern populations closely resemble *J. eubulus* (Common and Waterhouse 1981, Braby 2000). Eastwood *et al.* (2008) noted that populations from the Binjour Plateau, Krombit Tops, Toowoomba, Bunya Mountains and some more northern coastal areas have been considered to be *J. eubulus*, transitional or intermediate forms, a cline or a hybridisation zone between *J. eubulus* and *J. evagoras* (DeBaar 1977, Common and Waterhouse 1981, Dunn and Dunn 1991, Braby 2000, Sands and New 2002).

Although Waterhouse (1932) and McCubbin (1971) had suggested that, in addition to Brigalow (*Acacia harpophylla* F. Muell. ex Benth.), several other species of wattle served as food plants for *J. eubulus*, including *A. penninervis* Sieb. ex DC., *J. eubulus* was considered by Dunn *et al.*

(1994) and Eastwood *et al.* (2008), to be entirely dependent on mature stands of *A. harpophylla*. The solitary larvae of *J. eubulus* were said to feed only on *A. harpophylla* (Eastwood *et al.* 2008), whereas the gregarious larvae of *J. evagoras* were known to be oligophagous and to feed on at least 27 species of *Acacia* (Braby 2000).

Reports of *J. eubulus* ovipositing on an unidentified *Acacia* species, different from *A. harpophylla*, by Sands and New (2002), were not accepted by Eastwood *et al.* (2008) because identity of the host plant had not been confirmed and a subsequent search of the plant revealed no evidence of immature stages.

Dunn *et al.* (1994) and Yen and Butcher (1997) regarded the conservation status of *J. eubulus* as Vulnerable. After careful consideration, Sands and New (2002) recommended Vulnerable status for it in New South Wales and Lower Risk in Queensland, based on knowledge of the threatening processes pertaining at the time. Since then, several authors (Eastwood *et al.* 2008, Valentine and Johnson 2012, Braby and Williams 2016) have recognised the increasing threats to the mature brigalow habitats supporting *J. eubulus,* with Valentine and Johnson (2012) considering *J. eubulus* to be Endangered in Queensland and Critically Endangered in New South Wales.

Most authors, including Braby and Williams (2016), noted that *J. eubulus* was threatened due to its dependence on old growth *A. harpophylla* and that the decline in numbers was due to loss and destruction of the remnant breeding sites. *Jalmenus eubulus* is currently considered to be at risk from continuing habitat loss, invasion of the woodland habitats by highly-flammable Buffel grass (*Cenchris echinatus* L.) and grazing of the lower branches of *Acacia* spp., the breeding sites for *J. eubulus*.

Figs 1-2. Habitat and breeding sites for *Jalmenus eubulus* in Qld: (1) mature stand of *Acacia melvillei* at Jondaryan; (2) mature stand of *A. harpophylla* near Goondiwindi.

Here, we confirm that a species of Yarran, *Acacia melvillei* Pedley (Fig. 1), is a food plant in addition to the previously known *A. harpophylla* (Fig. 2) for the larvae of *J. eubulus* in southern inland Queensland.

Field observations, food plants and habitats of *J. eubulus*

At Jondaryan and near Chinchilla, Queensland, oviposition (Fig. 3), larvae and pupae of *J. eubulus* were observed on the leaves among small stems of the understory growth of *A. melvillei*, while at Jondaryan larvae were sometimes observed feeding on growth sprouting from fallen trees. Males at Jondaryan (Fig. 4) were observed congregating at a height of about 7 m, near the apex of *A. melvillei* trees. The eggs, larvae and pupae of *J. eubulus* on *A. melvillei* were attended by an unidentified black ant (Fig. 5).


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Figs 3-5. *Jalmenus eubulus* on *Acacia melvillei* at Jondaryan: (3) female ovipositing on understory growth; (4) freshly emerged male on understory growth; (5) fully-grown larva and freshly eclosed pupa, with attendant ants.

Yarran, *Acacia melvillei* (Fig. 1)
In Queensland, *A. melvillei* occurs mostly west of the Great Dividing Range: south of the Isaac River near Clermont, Charters Towers, Mitchell, Blackdown Tableland, Chinchilla, Jondaryan, Yaraka, west of Blackall (Lithgow 1997) and Thallon, near the New South Wales border. South of the Queensland-New South Wales border its inland distribution extends to Victoria. Pedley (1987) and Lithgow (1997) described the habit and growth of *A. melvillei* as a long-living tree reaching 15 m or more in height and with a trunk diameter to 30 cm, occurring often in groups of old growth trees on light soils and often in Poplar box (*Eucalyptus populnea* F. Muell.) woodlands. The yellowish, angular branchlets bear dark green oblong or elliptic phyllodes and the flowers are pale yellow to white.

Acacia melvillei is similar to a smaller species, *A. omalophylla* A. Cunn. ex Benth., both commonly referred to as Yarran and with an overlapping distribution in some areas. Whereas *A. melvillei* has yellowish green to greyish green phyllodes, the phyllodes of *A. omalophylla* are dull green to greyish green. *Acacia omalophylla* has not been observed to be a food plant for *Jalmenus eubulus*.

Brigalow, *Acacia harpophylla* (Fig. 2)
Acacia harpophylla forms a distinct plant community referred to as brigalow. It occurs in small patches in dryer regions of northern New South Wales and inland southern and central Queensland. Prior to clearing for agriculture, areas of brigalow were much more extensive than they are now (Eastwood *et al.* 2008). In Queensland, *A. harpophylla* occurs mostly, but not exclusively, west of the Main Divide from Hughenden to Rockhampton and from Clermont, Charleville, Dalby, Inglewood, Surat, Chinchilla and the Darling Downs to the New South Wales border. Remnant stands of brigalow also occur east of the Main Divide, for example, in the Brisbane Valley near Ipswich, Lockyer Valley at Gatton and near Boonah. In New South Wales, *A. harpophylla* is distributed from Boggabilla south-west to Bourke and south to Lake Cowal, 347 km west of Sydney.

Lithgow (1997) described the habit and growth of *A. harpophylla* in the Chinchilla district as a long-living tree reaching to 20 m in height with a trunk diameter to 60 cm. Mature trees often occurred as old-growth stands and originally formed extensive areas of thick scrub. The ribbed and slender branches bear golden flowers. The phyllodes of *A. harpophylla* are sickle-shaped and vary in colour from dull green to silvery blue-green or silvery grey; the pods are long and slender.

Discussion
Acacia harpophylla is the best-known food plant for *J. eubulus* in the inland regions of far northern New South Wales (De Baar 1977, Taylor 2014) and in southern Queensland (Waterhouse 1932, McCubbin 1971, Common and Waterhouse 1981, Braby 2000, Eastwood *et al.* 2008, Braby and Williams

2016). Larvae and pupae of *J. eubulus* are usually solitary but occasionally occur in pairs. A larva and a pupa may be found close to one anther.

Jalmenus eubulus has been observed breeding on *A. harpophylla* at a range of locations in Queensland south of Eungella, including Mt Moffatt and Carnarvon Gorge (Monteith and Yeates 1988), Theodore, Chinchilla, western Darling Downs, Millmerran (Brietfuss and Hill 2003, J. Macqueen and JFR Kerr pers. comms), Leyburn, near Goondiwindi (DPA Sands unpubl.) and in parts of the far north of inland New South Wales south of Boggabilla (De Baar 1977, Taylor 2014).

Figs 6-7. *Jalmenus eubulus* male from Jondaryan: (6) upperside; (7) underside.

Adult specimens of *J. eubulus* from Jondaryan (Figs 6-7), where larvae were observed feeding (10.v.2010, 22.ii.2011 and 10.v.2016) at a study site only on *A. melvillei*, are identical to specimens from Millmerran and Chinchilla

reared from larvae feeding on *A. harpophylla.* At Jondaryan there are no mature stands of *A. harpophylla* near the breeding sites for *J. eubulus.* Larvae of *J. eubulus* have also been observed feeding (8.iv.2010) on *A. melvillei* south of Chinchilla, where *J. eubulus* uses both *A. harpophylla* and *A. melvillei* as hosts (DPA Sands pers. obs., Lithgow 1997: as '*Jalmenus* sp.'). At Chinchilla, both food plants have been observed with larvae on them within a few kilometres of one another. Variation in the colour of the phyllodes of *A. harpophylla* may have led to misidentifications of the food plants of *J. eubulus* in the past. For example, the phyllodes of *A. harpophylla* may appear silvery, blue-green or dark green and the latter colour forms superficially resemble the phyllodes of *A. melvillei.* However, the mature phyllodes of *A. melvillei* are considerably narrower than those of *A. harpophylla*.

Recognition of *A. melvillei* as a food plant for *J. eubulus* might explain some reports of *J. eubulus* ovipositing on another species of *Acacia* (Sands and New 2002). However, the records for *A. penninervis* (Waterhouse 1932, Common and Waterhouse 1981) remain unconfirmed. While *A. penninervis* var. *penninervis* occurs in the same inland regions of Queensland that support the two confirmed food plants of *J. eubulus* (*A. harpophylla* and *A. melvillei*), *A. penninervis* grows mainly on steep banks and on sandstone ridges (Lithgow 1997). The plant communities and the soil substrates associated with *A. penninervis* appear to be different from those of the 'old growth' and mature stands of *A. harpophylla* and *A. melvillei*, supporting the assertion by Eastwood *et al*. (2008) that *A. penninervis* is unlikely to be a larval food plant for *J. eubulus*.

There are very few localities where *J. eubulus* has been discovered breeding on *A. melvillei*. The uncommon mature stands of *A. melvillei* are unprotected and many are at risk of severe disturbance. On this food plant, *J. eubulus* is of conservation concern from clearing, weed invasion, fire, mining, grazing and other disturbances. It is unlikely that the discovery of *J. eubulus* breeding on *A. melvillei* will significantly alter the conservation status of *J. eubulus*.

Acknowledgements
We are most grateful to John Kerr and the late Murdoch DeBaar for providing information on the habitats and inland food plants of *J. eubulus* and *J. evagoras*, to John Kerr, Ted Edwards and Michael Braby for commenting on earlier drafts and to Deborah Metters, Megan Thomas and Bill MacDonald for comments on the variation in foliage of *A. harpophylla.*

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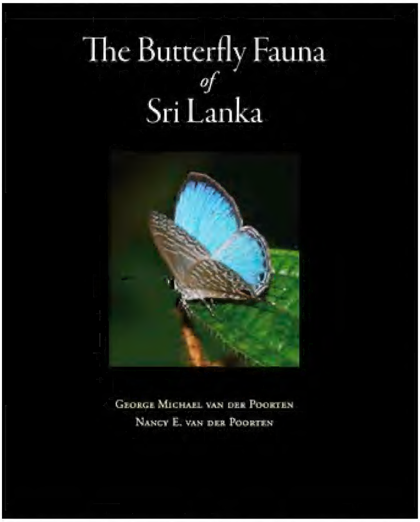
BOOK REVIEW

The butterfly fauna of Sri Lanka by George M. van der Poorten and Nancy E. van der Poorten. Lepedon Books, 2016; vi + 412 pp. ISBN 978 1 777136 189 7 (hardback). Price *ca* $75 incl. postage (from Book Depository: *http://www.bookdepository.com/The-Butterfly-Fauna-of-Sri-Lanka/9781771361897* 25/7/16).

The butterfly fauna of Sri Lanka was the first of any tropical region to be systematically documented. The seminal works of Moore and later Woodhouse & Henry remain classics in entomological literature. Both works provided illustrated accounts of all species known from 'Ceylon' at the time of writing, together with descriptions and illustrations of many early stages. Together they set a benchmark against which all future works would be judged.



The present book represents the first real advance in our knowledge of the Sri Lankan butterfly fauna in over 70 years. It documents the 247 species presently recognized from the island, with over 3200 photographs showing mainly adult butterflies in life, but also early stages (with larvae and pupae depicted for nearly 90% of species and eggs of 50%), parasitoids, host plants, nectar sources and habitats. Only a handful of dead, mounted specimens are depicted. For most species the living butterflies are exceptionally well observed, often with detailed notes on special behaviour, such as forced copulation by *Acraea terpsicore*, illustrated by a pair struggling on the ground, or the display of hairpencils during courtship by male *Idea jasonia*. Close-up details of structures are also depicted, such as the sphragis of a mated *A. terpsicore* female, or the everted double hairpencils of the male of *I. jasonia*. The book abounds in such details. There are also many photographs of butterflies in flight, nectaring, mud-puddling, courting, mating and ovipositing. The wealth of material is impressive and exciting. This is natural history at its best.

The text is authoritative and extremely well written. It begins with three highly informative introductory chapters dealing with Sri Lankan geography, zoogeography of its butterflies, general butterfly biology and conservation. Then follow family by family species accounts. Each species is given full page treatment under the usual headings, with conservation issues given particular attention. In cases of difficult groups, such as the Caeruleans (*Jamides*) or Lineblues, detailed illustrated keys are provided in separate boxes. The reader should have little trouble identifying most species. Illustrations of early stages are sometimes included in species accounts, alongside their descriptions, but more often they are confined to three appendices which show thumbnail photographs of, respectively, eggs, larvae and pupae. Other appendices include an annotated species list, a list of publications on Sri Lankan butterflies as well as an extensive general bibliography, a list of larval host plants, nectar sources, accounts of migration and a very complete glossary. Few stones are left unturned.

It is, overall, a remarkable achievement, a credit to its authors and obviously a labour of love. I strongly recommend it to anyone with a serious interest in butterflies, especially as it breaks new ground in the visual material presented and provides a model for a new type of butterfly book. It is a worthy successor to the iconic works of Moore and Woodhouse & Henry.

Reviewed by Albert Orr

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THE AUSTRALIAN
Entomologist

Volume 43, Part 3, 3 September 2016

ISSN 1320 6133